THE ART OF ORGAN-BUILDING.

VOLUME SECOND.

THE ART
OF
ORGAN-BUILDING

A COMPREHENSIVE HISTORICAL, THEORETICAL, AND PRACTICAL TREATISE

ON THE

TONAL APPOINTMENT AND MECHANICAL CONSTRUCTION OF CONCERT-ROOM, CHURCH, AND CHAMBER ORGANS

PROFUSELY ILLUSTRATED

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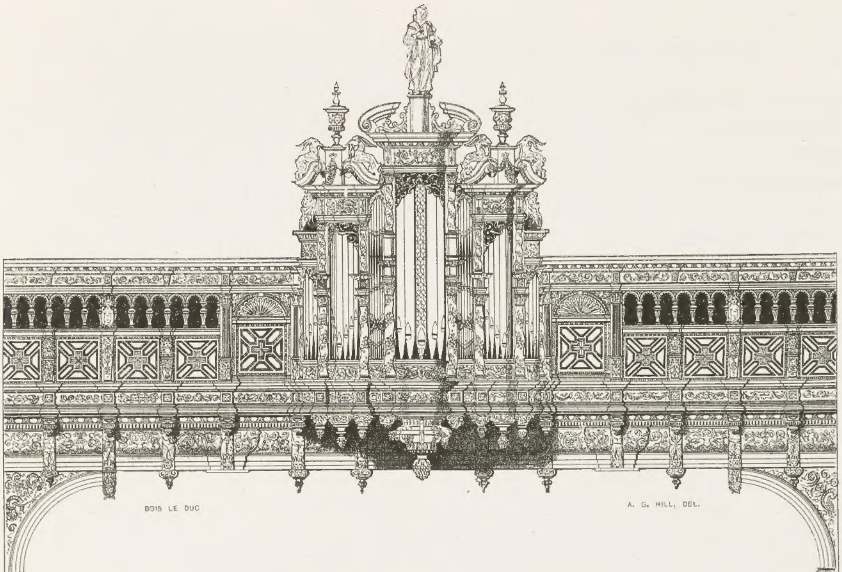


CHAPTER XV.

THE WEAKNESS AND THE AUGMENTATION OF THE TREBLE.

IN the present short Chapter we touch upon questions of some interest and importance to the student of organ-building, especially as they are intimately connected with the tonal appointment of the Organ. The questions are: Do Organs, as usually constructed and located, display any tendency to weakness in the treble portion of their compass? And if they do show a weakness; What is the best way of overcoming it in practical organ-building?

To the former question a conclusive answer has not yet been formulated; but researches go far to show that certain organ builders—men of considerable musical taste and great skill in their art—have evidently worked under a conviction that Organs treated in the ordinary way display a decided tendency to weakness in their treble octaves, or, in other words, an undue preponderance of tone in their bass and tenor octaves. It is probable that, in many instances, the tones of well-balanced instruments may have been so modified by the acoustical properties of the buildings in which they were placed, that an inequality of tonal effect between treble and bass became evident to the ear; and that this inequality may have seemed more or less pronounced to the listener in different

parts of the buildings is also highly probable. The simple fact that grave sounds travel farther and have more fulness and impressiveness than acute ones, is alone sufficient to account for an apparent weakness in the treble of an Organ, especially when the instrument is located in a very large church or cathedral, and commonly heard at a considerable distance from its situation. If a marching military band is listened to, it will be observed that the sounds of the Bass Drum will be heard before those of any of the other instruments; later, as the band approaches, the lower notes of the Bass Tuba and the other grave instruments strike the ear, then those of the tenor instruments, and, lastly, when much closer, the treble notes are heard. Such is the case, notwithstanding the fact that in the band the relative powers of the bass and treble sounds are much closer than they can ever be in Organs constructed on the present prevailing lines.

Leaving acoustical phenomena out of the question, there are causes in the present imperfect systems of tonal structure which go far to account for the absence of balance between the bass and treble octaves of the Organ. Most potent amongst these being an undue proportion of stops of 16 ft. pitch in the manual divisions; the too liberal introduction of a certain class of stops which have, in themselves, a decided disposition to become weaker as they ascend in the scale; and the usual adoption of one pressure of wind throughout the compass of the instrument. There can be no doubt that the use of "Doubles," or stops of 16 ft. pitch, in the manual divisions, has a tendency to weaken the treble, which even in well-balanced stops of the unison pitch (8 ft.) has enough to do to hold its own against its associated bass and tenor. In the case of a single, properly-balanced, Open Diapason, 8 ft., weakness in the treble can barely be realized; while the addition of an equally well-balanced Octave, 4 ft., practically removes any evidence of weakness. The further addition of a Double Open Diapason, 16 ft., will materially interfere with the balance, and a weakness in the treble will become apparent, especially if the ear is at a considerable distance from the Organ, and full chords are played. If a pedal part is also played the weakness becomes more striking. The stops which have an inherent weakness in the higher portion of the scale are the usual reed stops; and, under ordinary conditions, a liberal introduction of such stops, in any manual division of the Organ, is attended with a more or less decided loss of strength in the treble in comparison to the attendant bass: both have gained in power by the addition of the stops, but the bass has gained considerably more than the treble. The portion of the manual compass least disturbed is that embracing the two octaves lying between tenor C and c^2. There can be no question that the general practice of voicing and blowing stops on wind of the same pressure throughout their entire compass is conducive to comparative weakness in their treble octaves; and this effect has been observed by both old and modern builders. It is, indeed, unreasonable to look for a result different from that which universally obtains in stops so blown. When one turns to the wind instruments of the orchestra, the sounds of which are produced by the action of the lips and the wind from the lungs of the performers, one immediately recognizes the fact that as their tones rise in

pitch a proportionate increase in the pressure of the wind from the lungs is demanded; and that there is a great range of different pressures employed in producing the low, medium, and high notes of such instruments as the Horn, Trombone, and Trumpet. It is due to this increase of force in blowing that the higher tones of such instruments are as strong as their lower tones, if, indeed, they are not stronger, when heard close to the orchestra.* These observed facts in connection with the production of the different sounds in the orchestral wind instruments, guide the organ builder to one effective way of overcoming weakness in the treble.

* On this branch of our subject, the following words from the pen of M. Aristide Cavaillé-Coll may not be uninteresting:

"Si l'on considère, en effet, la puissance et la belle harmonie d'un orchestre composé d'une trentaine d'instruments seulement, comparativement à la faiblesse et à la maigreur des sons d'un orgue qui contient plusieurs milliers de tuyaux, on est étonné de voir que l'instrument qui réunit le plus de ressources ne déploie pas une plus grande puissance, relativement à sa grandeur. La principale cause de cette faiblesse réside pareillement dans la soufflerie, dont les dispositions connues jusqu'à ce jour ne permettaient pas de donner au son des tuyaux ni le volume ni le caractère qu'ils devraient avoir.

"Jusqu'à présent [1875], la pression du vent employé dans les orgues n'avait été que de 5 à 10 centimètres de colonne d'eau ; c'est entre ces deux limites que se trouvaient embouchées les orgues que nous avions eu occasion de vérifier avec un manomètre à eau : il est vrai que les jeux à bouche ou à flûte semblent devoir parler convenablement avec un vent de cette force ; mais il est certain que les jeux à anche (dans les tons élevés notamment) nécessitaient un vent plus comprimé.

"Cependant, dans la fabrication des orgues, on ne tient habituellement aucun compte de cette observation importante ; chaque facteur choisit le degré de pression qu'il juge convenable à son orgue, en sorte que la même pression s'applique à tous les jeux indifféremment. Il en résulte que les jeux à flûte sont exposés à être alimentés par un vent trop fort, tandis qu'au contraire les jeux à anche ont généralement un vent trop faible. De là vient principalement que les jeux de trompette, clairon et autres, perdent dans l'orgue le caractère des instruments à vent dont ils empruntent le nom ; car, indépendamment de l'influence que l'anche métallique peut exercer sur la qualité du son des tuyaux, au lieu de l'anche des instruments à vent formée par les lèvres de la bouche, il y en a une autre : c'est la pression du vent sous laquelle ces mêmes instruments résonnent.

"Il est facile de se convaincre en soufflant avec la bouche dans un manomètre à eau que la force du vent qu'on peut donner avec les poumons s'élève aisément à 50 centimètres d'eau et plus. J'ai vérifié par moi-même qu'elle arrive à 100 centimètres quand on souffle avec force.

"Maintenant, si l'on souffle dans un instrument à vent tel que le *cor* ou la *trompette*, on s'apercevra facilement, d'après l'effort avec lequel il faut souffler, que la pression du vent qui les fait sonner s'élève souvent à 50 centimètres d'eau, que les sons graves sont produits par un vent plus faible, et que les sons intermédiaires nécessitent une pression moyenne entre les deux.

"Ces considérations suffisent pour expliquer le peu de puissance des jeux de l'orgue comparativement aux instruments d'orchestre, car nous avons vu plus haut que la pression du vent le plus fort employé dans les orgues n'a été jusqu'ici que de 10 centimètres de colonne d'eau, tandis que dans les instruments à vent cette pression est de 4 à 5 fois plus considérable.

"Il n'est pas douteux que l'effet d'un orgue y gagnerait beaucoup, si l'on faisait parler les jeux à flûte avec la pression du vent qui leur convient. Les jeux à anche avec un vent plus fort tel qu'ils le réclament et mieux encore, que pour chaque période de son, d'octave en octave, il y eût un vent de l'intensité relative à la puissance qu'ils devraient avoir. Pour obtenir ce résultat, il fallait chercher une soufflerie qui fût susceptible de donner des pressions de vent différentes, afin que chaque jeu et les diverses octaves fussent pourvues de la force de vent nécessaire. Cette condition semble au premier abord facile à remplir, en appliquant une soufflerie différente pour chaque pression qu'on voudrait avoir ; mais, si l'on considère les inconvénients qui résulteraient d'une telle disposition, la question devient plus sérieuse. D'abord, la multiplicité des soufflets de cette soufflerie exigerait un vaste emplacement qui la rendrait impraticable dans le plus grand nombre de cas.

"Ensuite, comme la dépense du vent n'a pas lieu d'une manière uniforme, et qu'elle dépend du plus ou moins de jeux que l'organiste emploie, tantôt dans les notes graves, tantôt dans les tons élevés ou dans le médium, etc., il pourrait arriver qu'une soufflerie manquât de vent, tandis que les autres en contiendraient en abondance et que, par conséquent, le jeu de l'organiste se trouvât interrompu dans certaines notes du clavier pendant que les autres résonneraient comme avant ce contretemps.

"Pénétré de ces inconvénients, nous avons inventé un nouveau système de soufflerie qui remplit parfaitement les fonctions que nous avons indiquées plus haut. Il se compose d'une série de réservoirs superposés égale au nombre de pressions qu'on veut avoir et, quoique ces réservoirs soient alimentés par les mêmes pistons, la

In addition to the causes already alluded to, which may be said to be active in all Organs of the ordinary construction, there are others more subtile but still of considerable influence in increasing the inequality between the sounds of the lower and higher octaves of the manual stops. We allude to certain acoustical phenomena; chief among which are the generation of differential tones, as explained in the Chapter on The Tonal Structure of the Organ, and what is commonly known as sympathy. The generation of the differential tones is certainly more observable in the lower than in the higher octaves; and as the differential tones are invariably lower in pitch than the upper generating tones, and frequently lower than both the generating tones, the bass is sensibly increased in volume and strength, and much more so than are any of the higher octaves. In the latter the differential tones become weaker and weaker as they rise in pitch. The potency of the differential tones in the lower portion of the musical scale is well demonstrated by the generation of the so-called acoustic bass (32 ft. pitch) by the simultaneous sounding of stops of 16 ft. and 10⅔ ft. pitch. The differential tones, of 32 ft. pitch, are in this case distinctly heard. A single example in relation to the manual stops will suffice for our present purpose. If the CC pipe of the OPEN DIAPASON, 8 FT., is sounded along with the corresponding pipe of the OCTAVE, 4 FT., a differential tone will be produced of considerable strength, and this tone will be of the same pitch as the note yielded by the OPEN DIAPASON, and will, accordingly, go to increase the volume and strength of that note. In like manner, every pair of pipes throughout the manual compass will create a differential tone which will increase the lower note of the same. The differential tones, however, become comparatively weaker as they ascend the scale. In the case of a single OPEN DIAPASON, 8 FT., and its attendant OCTAVE, 4 FT., the differential tones have very little effect on the balance of tone the stops may possess; but in full combinations, including assertive reed stops, the differential tones, while they go far to enrich the general tonal structure, have a potent effect in increasing the difference of strength and assertiveness between the lower and the upper octaves of the manual compass; or, in other words, in increasing the relative weakness of the treble.

The old builders seem to have observed the tendency toward weakness in the treble of their Organs; but, with the exception of one very important example,

pression du vent qui leur est assignée ne peut être altérée en aucune manière par l'impéritie des souffleurs. La disposition de ces réservoirs est telle que, malgré l'intensité différente du vent que chacun doit fournir, ils communiquent entre eux au moyen de soupapes régulatrices et s'alimentent simultanément sans que jamais leur pression varie, ni qu'ils puissent manquer de vent tant qu'il y en a dans le 1er réservoir alimentaire. Ce système de soufflerie, comme on a pu le voir par ce qui précède, renferme en lui-même la source des améliorations importantes dont la qualité des sons du plus grand nombre des jeux de l'orgue est encore susceptible. Les jeux d'anches, principalement, se trouvant alimentés du grave à l'aigu par des pressions de vent d'autant plus fortes que les sons deviennent plus élevés, acquièrent ainsi un timbre homogène dans toute leur étendue qui met les dessus en rapport avec les basses. Les diverses pressions dont nous avons parlé sont également d'un grand secours pour emboucher convenablement les nouveaux jeux harmoniques. . . Un autre avantage qui résulte des principes sur lesquels repose cette soufflerie est celui d'éviter entièrement les secousses et les altérations qu'on remarque généralement dans les grandes orgues. Les nombreuses applications que nous avons déjà faites de ce nouveau système de soufflerie, notamment aux grandes orgues de St-Sulpice et de Notre-Dame de Paris, justifient surabondamment les avantages que nous venons d'énumérer."—"Projet d'Orgue Monumental pour la Basilique de St-Pierre de Rome." Bruxelles, 1875.

there appears to be no direct evidence of any decided measures having been taken by them to overcome that weakness by systematic augmentation. The builder of the celebrated Organ in the Cathedral of St. Bavon, at Haarlem, is the earliest who is known to have adopted a positive system of augmentation. In this instrument, which was constructed by Christian Müller, of Amsterdam, in the year 1738, we find certain stops in the manual divisions have their pipes duplicated in the higher octaves. The PRESTANT, 16 FT., (DOUBLE OPEN DIAPASON) and the OCTAAF, 8 FT., (OPEN DIAPASON) in the Great Organ, have both two ranks of pipes from middle c^1 to the top note. The PRESTANT 8 FT., (OPEN DIAPASON) in the Choir Organ, has two ranks from GG, to the top; and the PRESTANT, 8 FT., in the Echo Organ, has two ranks from A. It is quite evident that these very important stops were duplicated, as above described, for the purpose of augmenting the treble: and apparently with the same view four of the MIXTURES have their ranks increased in number as they break upward. Collectively, they have in their lower, middle, and upper divisions, XVIII., XXIII., and XXVIII. ranks.

Another noteworthy example, which may be considered as modern, shows a decided attempt to augment the treble by the addition of auxiliary pipes. We allude to the Organ in the chief Protestant Church at Utrecht, built by Batz, of Utrecht, in the year 1826. In the Great division of this important instrument all the stops with the exception of the two MIXTURES have two ranks of pipes from middle c^1 to the top. In all probability, many Organs built between the years 1738 and 1826, were treated in a somewhat similar manner and for the same purpose, but we have no records of them. The necessity for some system of augmentation of the treble was doubtless pressed upon the attention of the older German and Dutch builders by the effects produced by the stops of 16 ft. pitch, so liberally introduced by them in the manual divisions of their Organs; and by the large size and heavy character of the pedal departments of their instruments.

There can be no question that the strength and brilliancy of the treble sounds of the Organ are greatly impaired and obscured by the too liberal introduction or use of the manual Doubles; and also by the insertion of such stops, in scales and intonation, out of all proportion to the unison stops. It must be borne in mind, both by the organ builder and the organist, that 16 ft. tone has no necessary connection with the tonal structure of the manual divisions of the Organ; and that it has a greater power to disturb than to improve tonal structure. The 16 ft. tone belongs to the Pedal Organ, and only appears in the manual divisions as the means of imparting variety to certain combinations, and for the production of tonal effects rarely called for. Comparatively few organists have the correct conception of the office of the manual Doubles; and not one in a hundred uses them in a thoroughly artistic manner. To draw the Doubles in all full combinations is a serious blunder, from a musical point of view, yet it is an almost universal practice among the generality of organ players.

While the system of duplication, as illustrated by the Haarlem and Utrecht instruments, may appear to be both reasonable and desirable, it is, for certain reasons, not to be recommended, and chiefly because it has not been found to be reliable in practical organ-building. The acoustical or tonal aspect of the

system may be first considered. It is quite certain if the stops so treated are to retain their proper tonal character, that their duplicated ranks of pipes must be precisely similar in tone; and such being the case, there is considerable danger of the combined tones losing strength through what is known as acoustical sympathy, and the stops being injured rather than benefited by the duplication. The uncertain nature of this peculiar acoustical phenomenon will always interfere with anything approaching regularity of intonation in such stops. Among the objections to the system, advanced on purely practical grounds, may be named the additional expense entailed, the undesirable demand for increased size in the wind-chests, the greater consumption of wind, and the call for more labor and care in tuning. With all the drawbacks named, it is not probable that this system will ever again be adopted.

Somewhat akin to the above is the system which seeks to augment the treble by increasing the number of the ranks of the MIXTURES in their higher breaks. An example of this system is furnished by the Haarlem Organ. It is not too much to say that any builder who attempts to augment the treble by any special treatment of the compound harmonic-corroborating stops, loses sight entirely of the true and only office of such stops in the tonal structure of the Organ. There are enough of loud, screaming, and inartistic MIXTURES in existence, destroying good organ-tone in countless instruments; and in the name of art we protest against any increase of vulgarity in them, with the view of adding noise to any portion of the Organ. Every attempt that has been made to augment the treble by means of additional ranks or an increase of assertiveness in the higher octaves of the MIXTURES, has made matters worse instead of better.

There are other systems which deserve more careful consideration. These are augmentation by means of increased pressures of wind; augmentation by enlargement of the scales of the stops, upward: argumentation by the introduction of harmonic pipes; and augmentation by simple voicing and regulating.

M. Cavaillé-Coll seems to have been the first builder to devise the system of overcoming the weakness of the treble by means of increased pressures of wind, practically applying it in the Grand Organ he erected in the Royal Church of Saint-Denis, in the year 1841. In the Report on the construction of this instrument, submitted to the Société Libre des Beaux-Arts by J. Adrien de La Fage, we find the following interesting particulars respecting the wind supply and distribution: –

"There are eleven reservoirs, the eight larger of which contain each two thousand litres of compressed air, while the three smaller ones have a combined capacity of one thousand litres, making a total capacity of seventeen thousand litres. The eight large reservoirs are arranged in superposed pairs; each pair is fed by a piston attached to a lever worked by a man, supplying about ninety litres of air per second. The three other reservoirs, giving high pressure wind, are fed, in like manner, by a piston worked by a man, supplying forty litres of air per second; making a total supply of four hundred litres per second.

"The power necessary for operating the entire blowing apparatus is equivalent to 50 *kilogrammètres*, which being divided gives 10 *kilogrammètres* to each of the five levers,

corresponding to the working power of a man, when only laboring a short time with frequent intervals of rest.

"A blowing apparatus of this large capacity was absolutely necessary to supply an instrument of so great a size and containing so many large stops: and the contents of the reservoirs and the supply of the feeders respond so well to the demands of the instrument, that playing upon it with all the stops drawn fails to disturb the wind or affect the tuning of the pipes. . .

"Many other advantages have been secured by the bellows arrangements and combinations. First, the different pressures allow the distribution to each stop and its octaves of wind of such pressures as are best calculated to develop its desired tones. The upper octaves of the reed stops have especially benefited, having acquired a much purer and more brilliant quality of tone. The upper octaves are well balanced with the bass octaves, without requiring the help of some compound stop, like a Cornet or Mixture, which, combining imperfectly with the treble octaves, would produce a sharp and noisy tone. Secondly, the variety of pressures has largely aided the proper voicing of the harmonic stops. . . Thirdly, the variety of pressures allows of the advantageous separation of the wind between the bass and the treble of the stops, and between the labial stops and the reed stops of the instrument. Such are the happy consequences of the divisions of the reservoirs and the various pressures."

In other Grand Organs built by Cavaillé-Coll, notably those in Saint-Sulpice and the Cathedral of Notre-Dame, at Paris, the same system of increased wind pressures has been adopted, with great advantage to their tonal balance.

Of the augmentation of the treble by means of increased pressures of wind certain important examples exist in Great Britain. The earliest essay in this direction in England, of which we have any knowledge, was made by Hill, in the large Organ constructed by him for the London Panopticon, in the year 1853. Different pressures of wind were used throughout a certain portion of this instrument for the purpose of increasing the power of the treble pipes; but with what result we have been unable to ascertain. It may be said, however, that the builder, who was unquestionably an artist, considered the Panopticon Organ his greatest work. This Organ was removed from the Panopticon, and erected in the south transept of St. Paul's Cathedral, London. After lending its aid for some time to the special services held under the dome, it was taken down and somehow disposed of.

In the year 1859, Messrs. Gray & Davison, of London, erected the large Concert-room Organ in the Town Hall of Leeds, in which we find different pressures used to augment the treble of the Great Organ. The twenty-six stops of this division are planted on nine wind-chests, and the wind with which they are blown is increased in pressure twice in the range of their compass. The lowest pressure affects the labial stops and two reeds from CC to G, inclusive; the second pressure from G♯ to d^2, inclusive; and the third pressure from $d\sharp^2$ to c^4, inclusive. Four of the reed stops of this division are on heavier wind than the labial stops, and this wind is also increased at the notes above named, completing the augmentation of the entire treble of the Great Organ. No other division of this important instrument has this system of augmentation applied to it.

We now come to a very important and successful example of the system under consideration, presented by the large Organ erected by Messrs. T. C.

Lewis & Co., of London, in the Public Halls, Glasgow, in the year 1877. Here, as in the Organ in the Town Hall of Leeds, the system is confined to the Great division of the instrument. The accompanying diagram, Fig. LXIX., which shows the disposition of the six wind-chests of the Front and Back Great Organs,

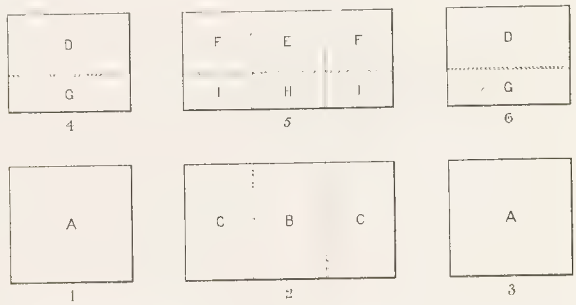


FIG. LXIX.

will assist in making the apportionment of the winds of different pressures clear to the reader. The three wind-chests, numbered 1, 2, 3, are planted with the following stops, which constitute the tonal appointment of the so-called Front Great Organ :

DOUBLE OPEN DIAPASON . .	16 ft.	TWELFTH	$2\frac{2}{3}$ ft.
OPEN DIAPASON—Large . .	8 "	FIFTEENTH	2 "
OPEN DIAPASON—Small .	8 "	SESQUIALTERA . . .	IV. ranks
ROHRFLÖTE . . .	8 "	TRUMPET	8 ft.
OCTAVE	4 "		

The central wind-chest, 3, is divided into three portions, as indicated by the transverse dotted lines, so as to admit of the augmentation of the treble. The bass and lower tenor pipes are planted on the two wind-chests A, A, extending from CC to G=20 notes. These speak on wind of the moderate pressure of 3 inches; quite sufficient, however, to produce a fine and pure bass quality from the combined stops. On the central portion of the middle wind-chest, B, are planted the pipes from G♯ to c♯^{1}, inclusive, on wind of $3\frac{1}{2}$ inches pressure: and on the lateral portions, C, C, are planted the treble pipes from d^1 to c^4, inclusive, on wind of 4 inches pressure.

The three wind-chests, numbered 4, 5, 6, are divided both longitudinally and transversely, as indicated by dotted lines, into ten compartments, which are planted with the nine stops of the Back Great Organ in the following manner: On the compartments D, D, E, F, F, are planted the six labial stops of this division; namely:—

Bourdon	16 ft.	Harmonic Flute	4 ft.
Viola	8 "	Octave Viola	4 "
Hohlflöte	8 "	Mixture	V. ranks.

These are supplied with wind of 3, 3½, and 4 inches pressure, in precisely the same manner as are the stops of the Front Great Organ. On the compartments G, G, H, I, I, are planted the three reeds of the Back Great Organ—Double Trumpet, 16 ft.; Trombone, 8 ft.; Clarion, 4 ft.—supplied with wind of higher pressures than the foregoing. The bass and lower tenor pipes, from CC to G, planted on the compartments G, G, speak on wind of 4 inches; the pipes, from G♯ to $c\sharp^1$, inclusive, planted on the compartment H, are on wind of 5 inches; and the treble pipes, from d^1 to c^4, planted on the compartments I, I, speak on wind of 6 inches pressure. Accordingly, the complete Great Organ has five distinct pressures of wind, and five special reservoirs for its supply; the three pressures applied to the labial stops increasing by steps of half an inch, and those applied to the three reed stops by steps of one inch. The arrangement is skilful, and its tonal results are very satisfactory; so much so, that it is to be regretted that in so important an instrument the same arrangement was not extended to the Swell and Solo Organs. The chief practical difficulty which attends this system, apart from that of finding room for so many special reservoirs, is the perfect joining of the tones of the pipes where the increase of pressure occurs. This, however, is only a serious difficulty under the hands of an indifferent voicer.

When an Organ is placed in a large building, and when it has, under general conditions, to be heard at a considerable distance, there can be no question that the system of augmentation by means of increased pressures is the most satisfactory: this is so because the *carrying power* of the treble sounds is greatly increased. It is weakness in this direction that, in the generality of instances, suggests the advisability, if not the necessity, of employing some method of augmentation. In the case of small Organs, or of those placed in small buildings, we do not recommend the adoption of augmentation by increased pressures.

From the examples given from the works of three leading English builders, it will be observed that increased pressures, for the purpose of augmenting the treble, have been confined to the Great Organ. This practice cannot, however, be logically supported, or altogether approved of, except, perhaps, in the case of instruments placed in some peculiar positions in churches of moderate dimensions; and even in them it is questionable if the Great is the division which most calls for the augmentation.

In Concert-room Organs, the divisions which call most imperatively for treble augmentation are those which contain the more important reed and the principal imitative stops. If any single division is to be selected, we are strongly of opinion that it should be the Solo Organ, which, in a properly appointed instrument, will be certain to contain imitative stops which benefit in the highest degree by treble augmentation. Of all the stops in the Organ the reeds benefit most from the augmentation of the treble by increased pressures; simply because the inherent weakness of their treble tones, in comparison to their bass and tenor ones,

is self-evident and universally acknowledged; and because no other system of augmentation can be effectively applied to them.

In the Glasgow Organ, Mr. T. C. Lewis has, by increasing the wind-pressures for the labial stops by half an inch at each step, and for the reed stops by one inch at each step, most unquestionably followed the correct method; and his example is as worthy of imitation, as it is to be properly chronicled.

The system of augmentation by means of enlargement of the pipe scales, upward, is one that has been frequently adopted by artistic builders; and it deserves to be well considered in the stop appointment of all classes and sizes of Organs. It cannot, however, be applied equally to all stops. The OPEN DIAPASON, for instance, in which augmentation of the treble would be most valuable, does not lend itself to anything approaching an extreme treatment; for when its treble pipes are increased in scale beyond a desirable ratio they begin to lose the beautiful diapason-tone, and become objectionably fluty in character. Stops of the flute family generally admit of enlargement of scale without any loss of tonal character. Hill and Willis sometimes used ratios which place the half diameter at the twenty-first and twenty-ninth pipe, counting the starting pipe in both cases. Examples of the former ratio are to be found in certain LIEBLICHGEDECKTS made by Hill; and of the latter ratio in the beautiful CLARIBEL FLUTES and HARMONIC FLUTES made by Willis. This exceptional ratio we are informed by an organ expert is to be found, in the above-named stops, in the Organ in the Church of Hoddesdon, Hertfordshire. Reed stops, under certain limitations, admit of enlargement of scale, and, accordingly, contribute somewhat to the augmentation of the treble. This reasonable enlargement of scale should be combined with increased wind pressures, when the latter obtain in any division of the Organ. Augmentation by enlargement of scale may properly be used for all suitable stops in the divisions of the Organ in which no other system of augmentation of the treble is introduced, where it should be rendered as effective as possible by appropriate voicing.

The system of augmentation of the treble by means of harmonic pipes was first introduced by Cavaillé-Coll—the inventor of the harmonic stops—in his fine Organ in the Royal Church of Saint-Denis. La Fage, in his Report, says:—

"Another improvement has been introduced in the Saint-Denis Organ, the advantages of which are much more evident [than those previously mentioned]. The stops of the old Organs, fabricated by good builders, were very satisfactory in regard to construction and quality of tone; and nothing was to be done but to imitate them; and if possible to add entirely new stops to the list. Among the stops of the Saint-Denis Organ, several have been listened to with that surprising interest which attends the audition of a new instrument. M. Cavaillé-Coll has not only introduced one stop, but, indeed, an entire family of new stops; and this new introduction is not only one of his best and most successful essays, but one of the most advantageous applications of science to musical art. . . .

"Hitherto only the ground tones of open and stopped pipes have been made use of in organ-building, and certainly they are the tones most easily obtained: but the fact that open pipes yield much brighter and stronger sounds than stopped ones strengthened the hope that great results might be obtained with pipes, the column of air in which, by being divided into several vibrating portions, would produce, with the same length of tube,

the octave, the twelfth, the super-octave, etc. The sound of an open pipe being, as regards its intensity, the equivalent of that of two stopped pipes of half the speaking length of the open pipe, it may be said that a harmonic sound is, in regard to its intensity, equivalent to the combined sounds of as many stopped pipes, yielding the same note, as there are vibrating portions in the over-blown open pipe. These acoustical phenomena were first practically applied in organ-building by M. Aristide Cavaillé-Coll.

"It was only after many experiments that he succeeded in fixing in every pipe the desired harmonic so as to obtain a homogeneous series of sounds proper to form a stop. Even, as it has been said by one of the most learned acousticians of the present century, 'when one tries to make a practical application of ideas apparently in accordance with theory, nature often denies our conjectures and opposes them with unforeseen hinderances: and after working for a long time, one is obliged to throw aside the fruits of all previous labors and make a new commencement. All these trials of patience are, however, forgotten so soon as success is achieved.' This was M. A. Cavaillé-Coll's experience; and the stops produced by him are superior to the ordinary stops both as regards the fullness and strength of their tones, and their perfect imitation of the sounds of the instruments they are designed to represent.

"The principle of the harmonic sounds being applicable to certain stops, it is evident that through the same the sounding part of the Organ has been greatly improved. This would have been sufficient to distinguish the Saint-Denis Organ above all other instruments. Its application has enabled the builder to considerably increase the power and fullness of the trebles, securing a perfect uniformity in the strength and tonal character of the bass and treble. The new system of bellows has considerably contributed to the success of the newly invented harmonic stops."

Valuable as the harmonic series of stops have proved to be, in the hands of such an artist as Cavaillé-Coll, for augmenting the treble sounds of the Organ by increasing their strength and traveling power, they must be recognized as only one means toward a desirable end. The sounds produced by the harmonic pipes are special and distinctive, and admit only of a limited introduction in any single instrument; and they are by no means the most important voices in the tonal appointment of the Organ: such being the case, only a moderate amount of assistance can be obtained from them toward a general augmentation of the treble. They are, however, decidedly valuable in this direction in conjunction with other expedients. To produce the best results, the harmonic stops call for increased pressures of wind. In the HARMONIC FLUTE, 8 FT., the harmonic pipes rarely go below middle f^1, this being the note at which they commence in the FLÛTE HARMONIQUE, 8 FT., in the Organ in Manchester Town Hall, built by the inventor of the stop. In the HARMONIC FLUTE, 4 FT., the harmonic pipes usually commence at tenor F, the pipe there being the same length as the f^1 pipe in the 8 ft. stop. In the HARMONIC PICCOLO, 2 FT., it is not advisable to carry the harmonic pipes below tenor C. These stops are properly carried down to CC, on the manual claviers, by open pipes of the ordinary speaking lengths. In the FLÛTE HARMONIQUE, 8 FT., in the Manchester Organ, the bass pipes are of open wood of standard speaking lengths; the tenor pipes, from C to E, are of open metal of standard lengths; and from F to c^4, the pipes are of open metal double the standard speaking lengths, yielding the harmonic octave tone.

Great care must be taken in voicing and regulating harmonic stops for Organs having only one pressure of wind, for there is a great danger of their

tones being practically lost by absorption. This is notably the case with those of 4 ft. pitch, whose tones are very liable to be drawn downward and absorbed by the powerful tones of the OPEN DIAPASON and other loud unison stops. This tendency may sometimes be counteracted by planting the harmonic stop at the greatest possible distance from the unison stop most likely to affect it. The introduction of harmonic stops will only be safe in the hands of artistic builders; and desirable only for instruments in which proper arrangements are made for their reception, and when expense is not so great a consideration as excellence of tone and construction.

We now come to the last system; namely, the augmentation of the treble by means of skilful voicing and regulating. While it is reasonable to suppose that every voicer who has any artistic feeling or knowledge of the fitness of things realizes the importance of imparting to the trebles of his stops as great a strength and brilliancy as they will stand without impairing their true tonal character; yet we are unaware of any systematic efforts having been made to test how far voicing and regulating may be made to overcome weakness of the treble. There can be no doubt, however, that much more can be done in this direction than is commonly understood or practiced. This method of augmentation has several advantages which should recommend it to all organ builders, and especially to those who are continually called upon to exercise rigid economy in the construction of their instruments. It does not necessitate the alteration of the usually accepted scales; it does not call for the expenditure of more material or the provision of additional space on the wind-chests; and it is not more expensive than the ordinary methods of voicing and regulating.

Of necessity, the question of voicing and regulating enters into all the systems of augmentation already touched upon. In that by increased wind pressures, the skill of the voicer is called upon to impart uniformity of tonal quality throughout the scale, and a gradual increase of strength and brilliancy, upward, to all stops. In the system of augmentation by the use of harmonic pipes, voicing and regulating are all-important; and the same may be said with regard to the system which involves the introduction of duplicate ranks of pipes.

On a careful and unprejudiced digest of all that has been said upon the subject of augmentation of the treble, the reader, we venture to think, can only arrive at one conclusion; namely, that for a perfect result in the case of an Organ of even moderate dimensions, all the systems, save that by duplication of pipes, must be adopted and carefully combined in the different manual divisions of the instrument, under the guidance of a true artistic feeling and musical taste, which will condemn any excess, or undesirable straining after illegitimate effects.

CHAPTER XVI.

BORROWING AND DUPLICATION.

AMONG the several objectionable practices which obtain in the modern system of organ-building there is none to be more severely condemned by those who realize what a correct tonal structure and an artistic tonal appointment mean, and who desire to see the Organ scientifically developed as a musical instrument, than the destructive system of *borrowing* which is advocated and resorted to in certain quarters to-day, apparently with the trade aim of making a small instrument look large on paper, and produce a considerable volume of sound at a cheap rate. It seems to be held by the advocates of this system that variety of *timbre* and tonal balance are of secondary importance to musical noise. We should think that no organ builder after reading the pamphlet written by M. H. V. Couwenbergh, entitled "L'Orgue Simplifié,"* would fail to see the utter absurdity of resorting to a wholesale system of borrowing stops or portions of stops from one manual division to create or largely augment other manual divisions. If we were not forced, by the general tone of the text of this remarkable pamphlet to recognize that the "Nouveau Système" was seriously advocated, we certainly should feel satisfied that the whole affair was intended as a cleverly organized joke.†

* "L'Orgue Simplifié ou Notice sur le Nouveau Système d'Orgues, inventé par M. Léonard Dryvers, Facteur d'orgues à Kessel-Loo-Louvain, Belgique, par H. V. Couwenbergh, Organiste à l'Abbaye d'Averbode." 1887.

† To assist the reader in arriving at a correct idea of the "Nouveau Système" we extract the following from the pamphlet alluded to.

"Simplifier l'orgue, tel fut de tout temps le rêve des facteurs. L'illustre abbé Vogler fut un des premiers à préconiser un système de simplification. A une époque plus récente on inventa en Allemagne le système de transmission, qui obtint quelques succès en Belgique et est encore employé par plusieurs facteurs, dans le but d'utiliser quelques basses du grand-orgue au clavier de pédales. Ce système donna lieu à un autre, qu'on a

To give support to our own remarks on the subject under consideration, it is only necessary to quote one of the Specifications given by M. Couwenbergh.

"GRAND ORGUE À TROIS CLAVIERS ET PÉDALES SÉPARÉES.

6 jeux formant 46 registres pour les deux premiers claviers et les pédales.

Un troisième clavier ou Récit expressif possédera tous les jeux qui ne sont pas répétés aux autres claviers.

Les six jeux qui forment les registres du Grand-orgue, Positif et Pédales sont :

1°	MONTRE 32	formant	11	jeux.
2°	BOURDON 32	"	10	"
3°	VIOLON 16	"	7	"
4°	FLÛTE HARMONIQUE 8	"	6	"
5°	BOMBARDE 32	"	8	"
6°	BASSON 16	"	4	"

AU GRAND-ORGUE.

1	PRINCIPAL 16,	—	de la MONTRE.
2	BOURDON 16,	—	du BOURDON.
3	VIOLON MAJEUR 16,	—	VIOLON 16.
4	MONTRE 8,	—	de la MONTRE.
5	BOURDON 8,	—	du BOURDON.
6	FLÛTE HARMONIQUE 8	—	FLÛTE HARMONIQUE 8.
7	VIOLE DE GAMBE 8,	—	du VIOLON.
8	PRESTANT 4,	—	de la MONTRE.
9	FLÛTE OCTAVIANTE 4,	—	de la FLÛTE HARMONIQUE.
10	VIOLINE 4,	—	du VIOLON.
11	DOUBLETTE 2,	—	de la MONTRE.

appelé depuis : système à dédoublement ou à jeux transformatifs, qui, comme son nom l'indique, consiste à dédoubler ou à transformer un jeu réel en plusieurs autres jeux indépendants. C'est ce système qui, il y a quatre ans, fut appliqué par MM. P. Schyven et Cie, facteurs d'orgues à Ixelles-Bruxelles.

"Mais l'idée du dédoublement, qui consiste, sommairement parlant, à obtenir des effets de puissance avec peu de tuyaux, ne fut plus chose nouvelle, lors de l'application qu'en firent MM. Schyven et Cie en 1884 et même à une époque antérieure (1872) MM. Delmotte, frères, facteurs d'orgues à Tournay. M. Léonard Dryvers, en effet, alors facteur d'orgues à Rotselaer, construisit en 1871 des orgues à dédoublement, chez les Dames Ursulines à Liérre et à Werchter (paroisse.) Les procédés employés par lui, furent loin de ressembler à ceux dont MM. Delmotte et Schyven avaient fait usage. Ce que ces facteurs ont obtenu par une extension de la transmission et l'emploi des mêmes procédés, M. Dryvers l'avait déjà trouvé à un degré de perfection bien plus éminent ; par l'action des pièces mécaniques sur une même soupape. Ainsi il était arrivé à former avec 7 séries de tuyaux, plus de 35 jeux dédoublés, répartis sur tous les claviers à mains et les pédales indistinctement.

"Ce premier système, bien qu'il fut encore bien défectueux, mérita cependant l'approbation des amis et connaisseurs de l'art, qui ne surent s'empêcher d'en admirer la frappante originalité. Un des grands facteurs belges me disait naguère avec l'élan de la plus entière conviction : '*M. Dryvers est sorti d'un coup de l'ornière habituelle de la facture des orgues.*'

"M. Ch. Anneessens, facteur d'orgues à Grammont, écrivit à propos du dédoublement Schyven : 'Quant-aux claviers à mains, je n'admettrais le dédoublement que comme un *pis-aller* dans une nécessité absolue et pour des cas exceptionnels ; *encore emploierais-je pour le réaliser plutôt le procédé de M. Dryvers. Ce*

12	Flûte Champêtre 2,	—	du Bourdon.
13	Piccolo 1,	—	de la Montre.
14	Trompette 16,	—	de la Bombarde.
15	Trompette 8,	—	de la Bombarde.
16	Clairon 4,	—	de la Bombarde.

AU POSITIF.

17	Bourdon 16,	—	du Bourdon.
18	Principal 8,		de la Montre.
19	Flûte Harmonique 8,	—	Flûte Harmonique 8.
20	Viola 8,	—	du Violon.
21	Bourdon 8,		du Bourdon.
22	Prestant 4,	—	de la Montre.
23	Flûte Octaviante 4,		de la Flûte Harmonique.
24	Flûte Douce 4,		du Bourdon.
25	Violine 4,	—	du Violon.
26	Octavin Harmonique 2,	—	de la Flûte Harmonique.
27	Basson 16,	—	Basson 16.
28	Basson-Hautbois,	—	du Basson.
29	Trompette 8,	—	de la Bombarde.

PÉDALES.

30	Montre 32,	—	Montre 32.
31	Bourdon 32,	—	Bourdon 32.
32	Contre-Basse 16,		de la Montre.
33	Violon Basse 16,	—	du Violon.
34	Sous-Basse 16,		du Bourdon.
35	Montre 8,	—	de la Montre.
36	Flûte Ouverte 8,	—	de la Flûte Harmonique.

procédé est exempt des défauts du système par transmission ; chaque tuyau a son vent séparé, toujours le même ; le mécanisme, compliqué en apparence, à cause d'un assez grand nombre de pièces, est simple en réalité, parce que toutes ces pièces fonctionnent d'une manière identique ; il est d'ailleurs facile à atteindre dans toutes ses parties et d'un réglage aisé et sûr.'

"Cependant le procédé ne satisfit pas l'inventeur lui-même, c'est pourquoi il renonça à son brevet de 1873. Mais l'idée qui germa dans son cerveau, depuis nombre d'années, ne put tarder de se réaliser définitivement et d'une manière entièrement neuve, surpassant sous tous rapports tout ce qu'on a fait en ce genre jusqu' aujourd'hui. Tel est le système dont il s'agit ici.

"Les longues et étroites gravures, les coulisses et nombreuses soupapes des sommiers ordinaires, sont remplacées par un mécanisme fort simple, composé de rouleaux et balanciers faits en cuivre et en fer et incapables d'être susceptibles des mille dérangements d'un mécanisme ordinaire.

"Chaque tuyau a son vent séparé. Cette disposition procure à ce système une régularité inaltérable dans l'harmonie des jeux, et une grande abondance de vent, distribuée en quantité suffisante et toujours égale à chacun des tuyaux en particulier en proportion de ses dimensions et de son intonation.

"M. Dryvers a poussé l'économie des tuyaux à la dernière limite du possible : avec 4 séries de tuyaux de 16 pieds, il forme 31 jeux ; avec 6 séries de tuyaux de 32, 16 et 8 pieds, il forme plus de 46 jeux parfaitement indépendants et répartis sur tous les claviers indistinctement. Nous faisons suivre deux devis d'orgues modèles construits d'après ce système et nous avons eu soin de placer en regard des jeux dédoublés, les jeux réels dont ils sont tirés."

37	VIOLON 8,	—	du VIOLON.
38	FLÛTE BOUCHÉE 8,	—	du BOURDON.
39	OCTAVE 4,	—	de la MONTRE.
40	FLÛTE DOUCE 4,	—	du BOURDON.
41	BOMBARDE 32,	—	BOMBARDE 32.
42	BOMBARDE 16,	—	de la BOMBARDE.
43	BASSON BASSE 16,	—	BASSON 16.
44	TROMPETTE 8,	—	de la BOMBARDE.
45	BASSON 8,	—	du BASSON.
46	CLAIRON 4,	—	de la BOMBARDE.

RÉCIT EXPRESSIF.

Système ordinaire.

1 SALICIONAL 8.
2 FLÛTE HARMONIQUE 8.
3 VOIX CÉLESTE 8.
4 FLÛTE D'ÉCHO HARMONIQUE.
5 KÉRAULOPHONE 4.
6 COR ANGLAIS 16.
7 MUSETTE 8.
8 VOIX HUMAINE 8.

Les jeux suivants sont destinés à être accouplés au Grand-orgue:
9 QUINTE 5⅓.
10 FOURNITURE 7 rangs.
11 CORNET 5 rangs.

PÉDALES ACCESSOIRES.
12 Tremblant.
13 Accouplement du Récit au Grand-orgue.

Résumé: Grand-orgue, 16 jeux. | Pédales . . . . . 17 jeux.
Positif . . 13 " | Récit . . . . . . 11 "

Nombre de tuyaux : 1579, dont 540 au Grand Orgue et 1039 au Récit expressif."

From the above figures we gather that the compass of the manual divisions is CC to g^3=56 notes, and that the six stops which enter into the composition of the Grand-orgue, Positif, and Pédales are of extended and necessarily varied compass. To clearly show the ridiculous character of this travesty of tonal appointment, which may not at once strike the ordinary reader, we may enumerate the various stops which are derived from three of the fundamental stops:

From the MONTRE, 32 FT. (116 pipes), are derived the MONTRE, 32 FT.; CONTRE-BASSE, 16 FT.; PRINCIPAL, 16 FT.; PRINCIPAL, 8 FT.; MONTRE, 8 FT.; PRESTANT, 4 FT.; OCTAVE, 4 FT.; DOUBLETTE, 2 FT.; and PICCOLO, 1 FT.

From the BOURDON, 32 FT. (104 pipes), are derived the BOURDON, 32 FT.; SOUS-BASSE, 16 FT.; BOURDON, 16 FT.; BOURDON, 8 FT.; FLÛTE BOUCHÉE, 8 FT.; FLÛTE DOUCE, 4 FT.; and FLÛTE CHAMPÊTRE, 2 FT.

From the VIOLON, 16 FT. (80 pipes), are derived the VIOLON BASSE, 16 FT.; VIOLON MAJEUR, 16 FT.; VIOLE DE GAMBE, 8 FT.; VIOLA, 8 FT.; VIOLON, 8 FT.; and VIOLINE, 4 FT.

When we realize that all the stops above set forth are in each class identical in tonal character and strength of voice, we may well ask "What's in a name?" In this "Nouveau Système," beyond the indication in some instances of pitch, the names are utterly valueless and for the most part misleading. We feel that we

have wasted too much valuable space in giving this ridiculous system—if system it can be called—additional publicity; but we have been led to do so because a similar system, equally bad, although much less pronounced, has been advocated and introduced of late in certain quarters.

There can be no doubt in the mind of any one who has studied the tonal structure of the Organ from a scientific point of view, and the tonal appointment from an artistic standpoint, that any system which involves the duplication or the borrowing, in whole or part, of stops from one manual division to create or materially enlarge another manual division is fundamentally and radically wrong. And it is beyond all question that no argument, based on trade grounds or any possible expediency, can bring such a system within the realms of scientific and artistic organ-building. When a stop, bearing a certain name, in one division is borrowed for another manual division, where it appears under quite a different name, a deliberate deception is committed. It may be claimed that this deception is of slight importance when portion of a stop of 16 ft. pitch in one manual division is made to serve as a stop of 8 ft. pitch in another division; and, perhaps, by a greater extension of its compass, to serve as a stop of 4 ft. pitch in still another division. Putting aside the matter of deception, what is to be said about tonal propriety? Suppose there is a CONTRA-GAMBA, 16 FT. (73 pipes), in the Great Organ, and a GAMBA, 8 FT., is borrowed from it in the Choir Organ, does it not stand to reason that if the CONTRA-GAMBA is properly voiced for the Great Organ, the borrowed GAMBA will be altogether too loud for so delicate a division as a properly-appointed Choir Organ? How is it possible, in artistic tonal appointment, to borrow stops suitably and effectively voiced for a Swell Organ to form an Echo Organ? To perpetrate such a system of borrowing, or so-called duplication, is to repudiate all the teaching of the phenomena of musical sounds; and to set at defiance the great principles on which a perfect tonal structure and an artistic tonal appointment are based.

Borrowing is destructive to a very serious extent of both tonal variety and strength. We maintain that no two stops in any Organ, however large, should be exactly alike in *timbre* or in strength of voice; and that when any two stops closely approach each other in *timbre* they should be widely apart in strength of voice. Until these conditions are realized and observed, artistic tonal appointment will never be reached. There are, doubtless, many organ builders, including M. Dryvers and those who favor his "Nouveau Système," who will consider such conditions a needless refinement; for to them plenty of sound at any price is the great thing. It is only necessary to glance at the scheme of the Organ given in this Chapter to see how completely M. Dryvers ignores both science and art.

Organ builders do not favor the use of the term *borrowing*, simply because it tells an honest and unmistakable story; preferring the term *duplication*, which seems to imply an amplification of some sort, attended by an undefined advantage tonally. We do not consider that the terms *borrowing* and *duplication* mean the same thing. In M. Dryvers' remarkable scheme for his remarkable Organ of fifty-seven stops, we find borrowing carried to the extreme limit, while duplication is also much resorted to. Borrowing properly consists in forming from one stop of

grave pitch and extended compass, one, two, or more stops of higher pitches and ordinary compass. The MONTRE, 32 FT., comprising 116 pipes, furnishes some admirable examples of borrowing. From it M. Dryvers borrows the following stops of different pitches: CONTRE-BASSE, 16 FT.; MONTRE, 8 FT.; PRESTANT, 4 FT.; DOUBLETTE, 2 FT.; and PICCOLO, 1 FT. Duplication properly consists in the introduction of two stops of precisely the same pitch, *timbre*, and strength of tone in different divisions of an Organ; or in employing one and the same stop in two different divisions. The MONTRE, 32 FT., also furnishes examples of duplication. From it M. Dryvers derives the following stops of similar pitches: MONTRE, 8 FT., in the Grand-Orgue; PRINCIPAL, 8 FT., in the Positif; and MONTRE, 8 FT., in the Pédales: and PRESTANT, 4 FT., in the Grand-Orgue; PRESTANT, 4 FT., in the Positif; and OCTAVE, 4 FT., in the Pédales. Every one of the stops here enumerated are of the same tonality and strength of voice, so far, at least, as it is possible to obtain uniformity throughout so great a compass.

While there can be no possible excuse for duplication, borrowing may be resorted to in the formation of an auxiliary Pedal Organ. To furnish a small pedal department with one or two stops borrowed from expressive manual divisions would be to add greatly to the artistic capabilities of an Organ. Unexpressive pedal departments are among the great shortcomings in organ-building today. Even instruments of the largest size should be furnished with auxiliary Pedal Organs, borrowed from suitable stops of 16 ft. pitch belonging to the expressive manual divisions. See Chapter on the Concert-room Organ: Vol. I., p. 298.

The ignorance of architects respecting the requirements of the Organ, and their frequent failures to provide proper accommodation for it, have led to the construction of totally inadequate pedal departments. A notable example of this is furnished by the Organ in the Town Hall of Manchester. In planning the large concert-room, the architect did not provide suitable accommodation for an Organ of the proper size: and, accordingly, when M. Cavaillé-Coll was instructed to build an important instrument for concert purposes, he found that it was impossible to place a properly proportioned Pedal Organ in the space given him. He was, therefore, only able to find room for two special stops, comprising 42 pipes each; namely, the CONTRE-BASSE, 16 FT., and BOMBARDE, 16 FT. From these two stops are derived the FLÛTE BASSE, 8 FT., and TROMPETTE, 8 FT. The SOUS-BASSE, 16 FT.; BOURDON DOUX, 8 FT.; and VIOLONCELLE, 8 FT., are borrowed from stops in the Grand-Orgue. Why the distinguished builder did not impart some expressive powers to the pedal department by borrowing from the Récit expressif must remain a mystery to every organ expert endowed with any artistic sense. M. Cavaillé-Coll expressed to us his great regret that, through the mistake of the architect, he had been unable to provide an adequate Pedal Organ without the necessity of resorting to borrowing—a practice with which he had no sympathy.

In conclusion, we may say that beyond the formation of an expressive auxiliary Pedal Organ, as above alluded to, we strongly condemn the practice of borrowing and duplication as unscientific, inartistic, and fatal to a perfect tonal appointment: its absurd side is eloquently set forth in the "Nouveau Système" of M. Léonard Dryvers.

CHAPTER XVII.

TABLATURE AND COMPASS OF THE ORGAN.

THE Organ has in the range of its sounds the greatest compass of all musical instruments. Its compass properly extends from the CCCC note, of 32 ft. pitch, to the c^7 note, the highest yielded by the five-octave stop of 1 ft. pitch, embracing ten complete octaves. The stop of 1 ft. pitch is the highest one introduced in a complete or unbroken form in the Organ, and is found in certain large instruments, constructed by A. Cavaillé-Coll, in which, however, it does not extend beyond the note g^3 of the manual clavier—yielding the true sound of g^6. In only one instance has a serious attempt been made to extend the compass downward (below CCCC) in special pipes; and it is to be hoped that this single attempt will remain unique;* for it is certain that nothing desirable is gained by producing vibrational effects which the ear utterly fails to recognize as musical sounds. Of the acoustical effects produced by the grave differential tones resulting from the simultaneous sounding of pipes belonging to stops of 32 ft. and $21\frac{1}{3}$ ft. pitch it is unnecessary to speak here.

The term *Tablature* is used to designate the system of signs employed to indicate the notes of different pitches yielded by the pipe-work of the Organ. Each key of both the manual and pedal claviers commands certain sounds which vary in pitch; and it is, accordingly, necessary that some system should obtain whereby the sounds or notes of the different pitches can be clearly expressed and realized.

The pitch of an organ stop, or the series of pipes producing a connected musical scale, is determined, in organ terminology, by the length of its lowest

*In the large Organ in the Centennial Hall, Sydney, N. S. W., is a reed stop in the pedal department supposed to yield sounds embraced in a 64 ft. octave. No determinate musical sounds of so grave a pitch can be recognized as existing. This fact has been conclusively proved.

pipe, and also by the position of that pipe on the clavier. Thus, a stop formed of open pipes, the lowest of which is of the normal speaking length of eight feet, and which extend throughout the compass of the clavier, is understood to be of 8 ft. pitch: while a covered stop of 8 ft. pitch and full compass has its lowest pipe of the length necessary to produce a note of the same pitch as the open pipe of the above-given normal speaking length. It is, therefore, usual to speak of the open stop as being of eight feet, and of the covered stop as being of eight feet tone. With respect to the change in terminology resulting from the position of the lowest pipe of a stop on the clavier, we may remark that the unison pitch of the manual divisions of the Organ is 8 ft., and that the lowest octave of their claviers is called the eight feet octave; accordingly, when an 8 ft. stop starts from CC, the lowest key on the clavier, it is correctly designated a unison stop; but should this stop be moved up an octave, so that its lowest (8 ft.) pipe falls on the tenor C key, it is considered a stop of 16 ft. pitch, notwithstanding the fact that its bottom, or 16 ft., octave is wanting. In like manner, should it be moved up two octaves, so that its lowest (8 ft.) pipe falls on the middle c^1 key, it is called a "half stop" of 32 ft. pitch. Under such circumstances as these, and to prevent confusion, it is necessary to have a definite tablature by means of which every tone can be individualized and its pitch defined.

Before recommending a tablature for the Organ suitable for general adoption, we may briefly review those which have been used in England and Germany at different times.

The German organ builders have long used a tablature which is open to some objections on account of its want of distinctness, and of the ease with which mistakes can be made in its use. In this tablature, the twelve notes of the 32 ft. octave are indicated by single capital letters *underneath* each of which are placed two short parallel lines, thus: $\underline{\underline{C}}$. This is designated the "double contra-octave." The twelve notes of the 16 ft. octave are indicated by single capital letters *underneath* each of which is placed a single horizontal line, thus: $\underline{C}$. This is termed the "contra-octave." The notes of the 8 ft. octave, called the "great octave," are indicated by single capital letters without any addition. The notes of the 4 ft. octave, or so-called "small octave," are indicated by single small (lower-case) letters without any addition; the notes of the 2 ft. octave, or "once-accented octave," are marked by single small letters *above* each of which is placed one short line, thus: $\overline{c}$; and each of the succeeding higher octaves have their respective notes distinguished by small letters above which are placed two, three, four, five, or more short horizontal and parallel lines. These octaves are designated the "twice-accented octave," "thrice-accented octave," and so on.

A more modern form of the German tablature obtains, in which the twelve notes of the 32 ft. octave are indicated by single capital letters having the figure 2 placed *below* and to the right of them, thus: C_2; the notes of the 16 ft. octave by single capitals having the figure 1 placed in a similar position; the notes of the 8 ft. octave by single capitals having a cipher placed in a similar position; the notes of the 4 ft. octave by small letters having a cipher placed *above* and to the right of them, thus: c^0; and the notes of the succeeding higher octaves are indi-

cated by single small letters having the figures 1, 2, 3, 4, etc., placed in a similar position. While there is nothing in the older German tablature to recommend it for present adoption, the system of distinguishing the notes of the treble octaves from middle c^1, as followed in the more modern form, is perfectly clear and suitable for general acceptance. In both the German systems of tablature the change of designation takes place, at every octave, on the note C; and this method is evidently the most convenient and logical, seeing that the lowest note on both the manual and pedal claviers is C, and that the highest note on the manual clavier of full compass is c^4.

The old English tablature differs greatly from those above described, both as regards the notes on which the change of designation takes place and the method employed to indicate the notes in the different octaves. While in the German tablatures the change of designation invariably occurs on all the Cs of the manual and pedal compass, in the old English tablature the change is made on all the Gs of the manual compass. This practice probably originated in the favorite downward range of the manual claviers in the numerous old instruments known as "G Organs." Until a very recent date (1898) the Grand Organ in St. George's Hall, Liverpool, was such an instrument; all its manual claviers extending downward to GGG: but at the present time the instrument is denuded of much of its original grandeur by having all the pipe-work below CC removed—a piece of short-sighted vandalism which it is extremely difficult to understand when one remembers the magnificent effects the late Mr. W. T. Best produced by using those grave notes in the rendition of complicated orchestral scores. All the five grand pipes from GGG to BBB, on the hundred speaking stops of the instrument, were sacrificed so that three treble pipes from $a\sharp^3$ to c^4 could be added to the stops without causing a slight addition to the wind-chests and action.

The practice of changing the designation of each octave on the Gs of the manual scale should now be abandoned by English builders; for under all existing conditions it is inconvenient and illogical; and to those accustomed to other systems somewhat confusing. These considerations have induced us to practically ignore it in the present treatise.

The mode of indicating the notes throughout the compass of the Organ according to the old English tablature is as follows: The lower four diatonic notes of the 32 ft. octave are indicated by four capital letters, thus: CCCC, DDDD, EEEE, and FFFF. From the next diatonic note to the fourth note of the 16 ft. octave the notes are indicated by three capital letters, thus: GGG, AAA, BBB, CCC, DDD, EEE, and FFF. From the next note to the fourth in the 8 ft. octave the notes are, in like manner, indicated by two capital letters, thus: GG to FF. From the next note, G, to the fourth note, F, in the 4 ft. octave each note is indicated by a single capital letter. From the next note to the fourth in the 2 ft. octave the notes are indicated by single small letters, thus: g to f. These have sometimes been further individualized by the term *middle*, as "middle c." From the next diatonic note to the fourth in the 1 ft. octave the notes are indicated by two small letters, thus: gg to ff, or by single small letters preceded by the word *treble*, as "treble c." From the next note to the fourth

in the ½ ft. octave the notes are indicated by three small letters, or by single small letters with the term *in alt* affixed, as "c in alt." From the next note to the fourth in the ¼ ft. octave the notes are indicated by four small letters, or by single small letters with the term *in altissimo* affixed. Now, while these modes of indicating the notes throughout the compass of the Organ have some advantages over the German, on the score of distinctness, they are too clumsy to be advocated for general use at the present time.

A modern writer on organ matters has suggested using the old English tablature up to the so-called "fiddle B," and from middle c, upward, the modern German tablature; but as this system retains the objectionable mode of changing the designation on the G notes in the lower octaves, it is, in our opinion, an illogical compromise—a falling between two stools.

The tablature which we have adopted throughout the present treatise recommends itself on account of its clearness, and its minimum liability to confusion and mistakes by writers and printers. As in the case of the German systems, the change of designation is made on the first note of each octave, starting with the lowest note of the 32 ft. octave; accordingly, the changing takes place on each successive C throughout the compass of the Organ.

The tablature proposed is as follows: The first seven diatonic notes, commencing with the 32 ft. C, are indicated by four associated capital letters,—CCCC, DDDD, EEEE, FFFF, GGGG, AAAA, and BBBB,—so whenever four letters so associated are used to designate a note, the mind will, without hesitation, locate that note in the 32 ft. octave. The next seven diatonic notes, commencing with the 16 ft. C, are indicated by three similarly associated capitals,—CCC, DDD, EEE, FFF, GGG, AAA, and BBB,—hence, three associated letters will invariably distinguish a note lying in the 16 ft. octave. The following seven diatonic notes, commencing with the 8 ft. C, are indicated by two capital letters,—CC, DD, EE, FF, GG, AA, and BB,—therefore, two associated letters will locate a note in the 8 ft. octave. The next seven diatonic notes are indicated by single capital letters,—C, D, E, F, G, A, and B,—hence, a single letter, without any attendant mark, will invariably distinguish a note lying in the 4 ft. octave. The succeeding seven diatonic notes, commencing with the 2 ft. C, are indicated by single small (lower-case) letters, having a small figure 1 placed above and to the right of them,—c^1, d^1, e^1, f^1, g^1, a^1, and b^1,—and these clearly distinguish the notes of the middle octave of the manual compass. The next seven diatonic notes, commencing with the 1 ft. C, are indicated by single small letters, having, in like manner, a small figure 2 affixed to them,—c^2, d^2, e^2, f^2, g^2, a^2, and b^2. The succeeding seven diatonic notes, commencing with the ½ ft. C, are indicated by single small letters, having a small figure 3 affixed to them,—c^3, d^3, e^3, f^3, g^3, a^3, and b^3. The notes of the still higher octaves are indicated by the same single small letters, having the small figures 4, 5, etc., affixed to them, as above. The highest unison note of the manual claviers of the full modern compass is c^4. All the tablatures above described are set forth in the accompanying table so that they may readily be compared. The table will also be found useful for general reference.

TABLE SHOWING DIFFERENT OLD AND MODERN SYSTEMS OF TABLATURE AS APPLIED TO THE ORGAN.

NORMAL LENGTHS OF PIPES	APPROVED TABLATURE	OLD GERMAN TABLATURE	MODERN GERMAN TABLATURE	OLD ENGLISH TABLATURE
32 FEET.	CCCC	$\underline{C}$	C_2	CCCC
	DDDD	D	D_2	DDDD
	EEEE	E	E_2	EEEE
	FFFF	F	F_2	FFFF
21⅓ FEET.	GGGG	G	G_2	GGG
	AAAA	A	A_2	AAA
	BBBB	B	B_2	BBB
16 FEET.	CCC	C	C_1	CCC
	DDD	D	D_1	DDD
	EEE	E	E_1	EEE [Double Bass]
	FFF	F	F_1	FFF
10⅔ FEET.	GGG	G	G_1	GG
	AAA	A	A_1	AA
	BBB	B	B_1	BB
8 FEET.	CC	C	C_0	CC
	DD	D	D_0	DD
	EE	E	E_0	EE
	FF	F	F_0	FF
5⅓ FEET.	GG	G	G_0	G [Gamut]
	AA	A	A_0	A
	BB	B	B_0	B
4 FEET.	C	c	c^0	C [Tenor]
	D	d	d^0	D
	E	e	e^0	E
	F	f	f^0	F
2⅔ FEET.	G	g	g^0	g [Fiddle]
	A	a	a^0	a
	B	b	b^0	b

NORMAL LENGTHS OF PIPES	APPROVED TABLATURE	OLD GERMAN TABLATURE	MODERN GERMAN TABLATURE	OLD ENGLISH TABLATURE
2 FEET.	c^1	c	c^1	c [Middle]
	d^1	d	d^1	d
	e^1	e	e^1	e
	f^1	f	f^1	f
1 1/3 FEET.	g^1	g	g^1	gg
	a^1	a	a^1	aa
	b^1	b	b^1	bb
1 FOOT.	c^2	$\bar{c}$	c^2	cc [Treble]
	d^2	$\bar{d}$	d^2	dd
	e^2	$\bar{e}$	e^2	ee
	f^2	$\bar{f}$	f^2	ff
2/3 FOOT.	g^2	$\bar{g}$	g^2	ggg [In alt.]
	a^2	$\bar{a}$	a^2	aaa
	b^2	$\bar{b}$	b^2	bbb
1/2 FOOT.	c^3	$\bar{\bar{c}}$	c^3	ccc
	d^3	$\bar{\bar{d}}$	d^3	ddd
	e^3	$\bar{\bar{e}}$	e^3	eee
	f^3	$\bar{\bar{f}}$	f^3	fff
1/3 FOOT.	g^3	$\bar{\bar{g}}$	g^3	gggg [In altissimo]
	a^3	$\bar{\bar{a}}$	a^3	aaaa
	b^3	$\bar{\bar{b}}$	b^3	bbbb
1/4 FOOT.	c^4	$\bar{\bar{\bar{c}}}$	c^4	cccc
	d^4	$\bar{\bar{\bar{d}}}$	d^4	dddd
	e^4	$\bar{\bar{\bar{e}}}$	e^4	eeee
	f^4	$\bar{\bar{\bar{f}}}$	f^4	ffff
1/6 FOOT.	g^4	$\bar{\bar{\bar{g}}}$	g^4	ggggg
	a^4	$\bar{\bar{\bar{a}}}$	a^4	aaaaa
	b^4	$\bar{\bar{\bar{b}}}$	b^4	bbbbb
1/8 FOOT.	c^5	$\bar{\bar{\bar{\bar{c}}}}$	c^5	ccccc

It is only necessary to pass a few remarks on the subject of the compass of the Organ as found in the pedal and manual claviers, of the Church, Concert-room, and Chamber Organs constructed at the present day. The subject has been so fully discussed in other works on the Organ that it is undesirable to devote much space to it in this treatise. The student who desires to acquire a comprehensive knowledge of it, in both its historical and practical aspects, will find materials sufficient to weary him in a work entitled "The Organ. Its Compass, Tablature, and Short and Incomplete Octaves." *

An examination of the various compasses of the Organ which have obtained from the period in which the instrument assumed a dignified form, approaching that with which we are now familiar, leaves us under the conviction that during the periods of the greatest changes no accepted rules were followed in the determination of the downward and upward limits of the claviers. Individual opinion and caprice appear to have largely dictated the compass; for it is difficult to discover any facts which tend to indicate that the several boundaries, adopted at different times and in different places, were the results of a serious consideration of the musical questions involved. These facts go far to render the historical side of the subject of little real value or interest.

The greatest diversity of compass has commonly showed itself in the downward range of the manual claviers; but the differences in the upward range have also been numerous: even at the present time, when the downward limits of the compasses of both the manual and pedal claviers have been practically settled and all but universally adopted, the upward limits of their respective compasses continue to vary. It is highly probable that before many years have passed a uniform upward boundary for each of the claviers will be permanently fixed for all Organs of any importance. It may be said that this boundary has practically been decided for the manual and pedal claviers of all Organs of the first magnitude.

In England, from about the middle of the seventeenth century until about the middle of the nineteenth, the approved downward range was to GGG ($10\frac{2}{3}$ ft.). So late as the year 1855 this range was adopted for the four manual claviers in the Grand Organ erected in St. George's Hall, Liverpool. Other ranges were sometimes used; namely, FFF, EEE (very rarely), and CCC. The last was used for the Great and Choir divisions of the Organ in Birmingham Town Hall, as constructed by Hill in 1836. The FFF range was used for the Great and Choir divisions of Green's Organ in Salisbury Cathedral, constructed in 1792. Since the middle of the nineteenth century the CC downward range has been accepted in Great Britain as that most convenient and desirable; and at the present time it is universally adopted there for all properly-appointed instruments.

In the United States, the CC downward range has always been in favor, both English and German influences leading to this desirable end. To-day this downward limit is invariably adopted for the manual claviers of all Organs of proper construction.

* By John W. Warman, A. C. O.—8vo., 156 pp. W. Reeves, London, 1884.

In Germany, the only downward range of the manual claviers which appears to have been systematically used is the CC. It certainly has been in favor since the middle of the sixteenth century; and was firmly established during the lifetime of Johann Sebastian Bach. It is probable that previous to the end of the seventeenth century the bottom octave was frequently introduced in an incomplete form; but Bach's great and immortal Fugues for the Organ prove that the downward range of the manual claviers was complete to CC, in Germany, in the early part of the eighteenth century. Since that time the correct downward compass has never been departed from by German organ builders.

In France, the CC downward range has in all important periods been accepted as the correct one for the manual claviers. In the great work by Dom Bedos, published in the year 1766, this note is clearly indicated in all the illustrations relating to the Church Organ. In the case of two Chamber Organs the lowest note of the clavier is DD; and in the case of two so-called "Table Organs," likewise illustrated, the notes FFF and GGG, respectively, appear as the downward limits of their single claviers. The CC limit is now universally adopted by the French organ builders.

In Austria, Switzerland, Belgium, and the Netherlands, the CC downward limit of the manual claviers has long been accepted as the one most desirable, and has very rarely been departed from since its sufficiency was realized. In Italy and Spain, although lower limits, such as CCC, FFF, and AAA, appear to have been held in some favor at different times, or for special instruments, the CC limit has gradually become recognized as the most convenient one in all instruments furnished with an independent Pedal Organ. Such a low limit as CCC was unquestionably valuable when the instrument contained no pedal pipes, and the pedal keys merely pulled down the lowest octave or so of the manual keys.

It is quite unnecessary to occupy valuable space by going at length into the arguments for and against the now universally accepted CC downward limit for manual claviers. It will be sufficient to briefly touch on those which most clearly point out the advantages attending its adoption, and which have led to its universal acceptance.

In the first place, the great works written for the Organ by the German masters—Bach, Mendelssohn, Hesse, and others—and also by the distinguished organists of both England and France, never descend below the CC key in their manual parts; accordingly, any notes added under that are of no use in the rendition of such music. There are exceptions to every rule; and in this case the exceptions are found in some works of lesser importance, written for Organs of lower manual compass, as in those by Samuel Wesley, Thomas Adams, and Doctor Wesley. Such works have no value in argument when placed against the countless grand compositions which have been written for the CC Organ. In the second place, as Dr. Hopkins says, "In the selected movements from the works originally written with orchestral accompaniments, such as the solos and choruses in oratorios, masses, etc., it will be observed that the Violoncello part, which comprehends within its downward range also that of all vocal basses, *never* descends below the CC note, which note is the lowest one on that instrument. The

Double Bass indeed is a deeper-toned instrument; yet, as it does not give a sound in accordance with the notes written, but the *octave below*, as far as its compass permits [EEE of the approved tablature], its representative is correctly to be found among the unison (16 ft.) flue-work [labial stops] of the Pedal Organ." It has been satisfactorily proved that the most complicated orchestral scores, transcribed for the Organ, can be correctly rendered on a large Concert-room instrument having CC manuals. Perhaps no Organ ever constructed has had, and still has, more exacting calls upon its resources, in this class of music, than the grand instrument in St. George's Hall, Liverpool; yet, although it was originally constructed with all its four manual claviers descending to GGG, it has lately been altered to the CC downward range, and all the very noble and expensive pipe-work of its large manual divisions below that note has been removed. In the third place, the CC downward limit is strongly to be recommended on the score of economy of space as well as that of money. Pipe-work carried below CC is both cumbersome and very costly; and the money that would have to be expended on it may, with the greatest advantage, be devoted to the improvement or proper appointment of the Pedal Organ, to which such grave pipe-work strictly belongs. It may be here stated that all CC Organs should be furnished with an adequate pedal department: indeed, the best argument that can be advanced in favor of the CCC or GGG manual range is that based on the existence of an altogether insufficient Pedal Organ, and the impossibility of obtaining sufficiently soft and varied basses therefrom.

In the above remarks we have not alluded to the fact—interesting only on historical grounds—that the different manual divisions of old Organs were frequently commanded by claviers of decidedly different downward ranges.* So objectionable a practice is never contemplated in the modern school of organ-building.

While it may be laid down as a hard and fast rule that the CC downward range should never be departed from in any of the manual claviers of Concert-room, Church, and Chamber Organs, it is neither necessary nor, perhaps, desirable to fix a definite upward limit for the same claviers. A certain freedom in this direction may be permitted, notwithstanding the fact that there is a note which all manual claviers should be carried up to when circumstances permit.

In England, the lowest upward range of the manual claviers which appears to have been used by the old masters of organ-building is c^3; but that generally preferred by them extended two notes higher, to d^3. The higher ranges, to e^3, f^3, g^3, a^3, and c^4, came into use at various later times; and the notes g^3, a^3, and c^4 are commonly adopted for instruments of different classes constructed at the present day. For a long time g^3 was considered the extreme limit necessary and desirable for Church Organs; and it is ample for all instruments employed for the accompaniment of the voice, and for the rendition of the great mass of legitimate ecclesiastical music: and, except in the case of very large instruments in which octave coupling is introduced, and on which all classes of music of a dignified

* For full information on this subject, the student may consult Mr. Warman's treatise, already mentioned.

character will be performed, in the proper order of things, the g^3 upward limit is sufficient. It is quite certain that no ordinary Church Organ need have its manual claviers extend beyond a^3; and this compass admits of a reasonable use of octave coupling. It may be remarked that while different bottom limits have frequently been adopted for the manual claviers in the same instrument, their top notes have invariably been alike. For, while several reasons could be advanced for the variations in their downward ranges, none could well be given for any variation in their upward limits. The highest upward range that the manual claviers have attained up to the present time is c^4, which gives them a compass of five complete octaves; and it is not at all probable that a higher limit will ever be adopted for the Organ. This compass is really necessary only in Concert-room Organs, although we strongly advocate it for Chamber Organs which are based—as all perfect Chamber Organs ought to be—on the Concert-room Organ model. This was the compass adopted for the large Chamber Organ constructed by Edmund Schulze for Mr. T. S. Kennedy, of Meanwood, and which now stands in the Church of St. Bartholomew, at Armley, near Leeds.

In America, the three notes g^3, a^3, and c^4 are adopted. The Roosevelt Organs in the Cathedral of Incarnation, Garden City, L. I., and Grace Church, New York, have all their manual claviers carried up to c^4. Of the g^3 and a^3 limits numerous examples exist in American Organs.

In Germany, Austria, Switzerland, Belgium, and the Netherlands, the shortest upward range that appears to have been adopted by the older builders is c^3. We find this top limit in the large Organ in the Church of the Benedictine Monastery, at Weingarten; and also in Silbermann's fine instrument in the Church of St. Thomas, at Strasbourg. The note d^3 has been frequently adopted, the Organ in the Cathedral of St. Bavon, at Haarlem, affording a prominent instance: and the note e^3 has been occasionally used, as in the Organ in the University Church, at Leipzig. The upward limit most commonly adopted is f^3, and this was seldom exceeded in Church Organs. The manual claviers of the large instrument in the Cathedral of Merseburg extend to the note g^3, furnishing one of the comparatively few examples of this compass. The Concert-room Organs in the Gewandhaus and Conservatorium, at Leipzig, constructed by Walcker, of Ludwigsburg, have all their manual claviers carried up to a^3, while the grand Organ in the Cathedral of St. Stephen, at Vienna, constructed in 1886 by the same firm, has its manuals extending only to f^3. This upward range is considered by the German builders sufficient for the Church Organ.

In France, the notes commonly adopted for the upward limit of the manual claviers of Church Organs are f^3 and g^3, the latter being considered sufficient for the most important instruments. The former limit is found in the Grand Organs in the Royal Church of Saint-Denis, and the Church of Saint-Eustache, at Paris; while the g^3 limit is found in the Grand Organs in the Cathedral of Notre-Dame, and the Church of Saint-Sulpice, at Paris, and also in the Grand Organ in the Church of Saint-Ouen, at Rouen.* We have not been able to find

* Speaking of the manual claviers of this fine instrument, M. Philbert remarks: "Les claviers à main sont restés au nombre de quatre. Comme à Saint-Sulpice et à Notre-Dame de Paris, chacune des deux laies du

a Church Organ in France having a higher manual clavier limit. The Concert-room Organ in the Salle des Fêtes of the Palais du Trocadéro, at Paris, constructed by Cavaillé-Coll in 1878, has all its four manual claviers terminating in g^3. Had this instrument been originally designed for the concert-room, it would have had its upward range extended, certainly to a^3, and in all likelihood to c^4. This Organ was intended for the Church of Notre-Dame, at Auteuil, but was transferred from the organ factory, in an enlarged form, to the Palais du Trocadéro of the Exposition Universelle of 1878.

With respect to the upward limit of the manual claviers of Concert-room, Church, and Chamber Organs, the following conclusions may be safely accepted.

No organ of any description should now be constructed with a lower upward limit in its manual claviers than g^3; and it should be adopted only for Church Organs of ordinary size and construction. This range provides an octave above the highest note of all sacred vocal music of the usual character; and, accordingly, is not likely to cause any difficulty or even inconvenience in the appropriate accompanying of the same. As before pointed out, this has been the upward limit most frequently adopted for Church organs in England and America, while it is recognized as sufficient by the French organ builders and church organists of to-day.

When expense is not an important consideration, the range to a^3 is strongly to be recommended for large Church Organs; for the additional two notes provided will frequently be found valuable in octave coupling, and in the rendition of numerous modern compositions for the instrument. We are strongly of opinion that no Chamber Organ, at all worthy of the name, should now be constructed with a shorter upper range than a^3; for it must be borne in mind that all classes of music suitable for the Organ will certainly be performed on it; and that it must be adapted in every way for *ensemble* performances of an exacting character.

While it is quite certain that the manual claviers of the Concert-room Organ should not have a shorter upper range than c^4, which gives them a clear compass of five octaves, it is advisable that the same range should be adopted for all important Church and Chamber Organs when space and funds are ample. This is unquestionably the ideal manual compass, now largely favored, and which will in the future be exclusively used for all Organs of any pretensions toward completeness. It favors the introduction of octave coupling on and between the claviers; and, accordingly, materially increases the tonal resources and effectiveness of the Organ.* It is not likely that a higher range will ever be systematically adopted, simply because there is a practical difficulty in carrying the pipes of the higher pitched stops beyond c^4. In addition to this, the fact that all the manual divisions contain stops of higher pitch than the unisons renders a greater compass of the claviers quite unnecessary.

grand-orgue est gouvernée par un clavier spécial. Le premier, qui a retenu le nom de grand-orgue, est principalement consacré aux jeux de fond, le second, qu'on a continué à désigner sous le nom de clavier de bombarde, mais qui, plus logiquement, devrait s'appeler clavier de grand-chœur, porte les mutations et les jeux d'anche ordinaires. Les autres sont le clavier du positif et celui de récit expressif. *Tous sont complets it ont l'étendue aujourd'hui généralement admise de cinquante-six notes d'ut en sol.*"

* In speaking of octave coupling in the present Chapter, we have not contemplated the desirable modern practice of extending the range of the double, unison, and octave pipe-work, planted on the wind-chests, an octave higher than the upward limit of the commanding claviers.

In the foregoing remarks we have not alluded to the fact that in many of the old Organs, constructed in England and elsewhere, the lowest octave of the manual claviers was frequently introduced in an incomplete state; and that the claviers so treated have been known as "incomplete" or "short octave" claviers. This treatment has no value with respect to the practice of modern organ-building; but is interesting from a historical point of view. It consisted in simply omitting certain notes presumed by the old builders to be of comparatively little value. In this direction we may give the information furnished in a concise form by Hiles, in his "Catechism of the Organ," without fully quoting the same.

In the sixteenth century the manual claviers had attained a compass of four octaves, comprising the chromatic notes or semitones; but in the lowest octave the notes or sounds of CC♯, DD♯, FF♯, and GG♯, were omitted. The keys of the clavier, therefore, in this octave did not obtain in the usual or correct order, but were carried down, apparently, only to EE. The arrangement was as follows: the bottom key, apparently EE, actually sounded the note CC; the next key, FF sounded its correct note; the next key, seemingly FF♯, actually sounded DD; the following key appeared and sounded GG; the next, apparently GG♯, sounded EE; and from the following key, AA, the proper order of keys and sounds obtained. This arrangement is shown in the accompanying diagram, Fig. LXX, which represents the lower portion of a manual clavier. The clavier so treated is known as a "short octave manual."

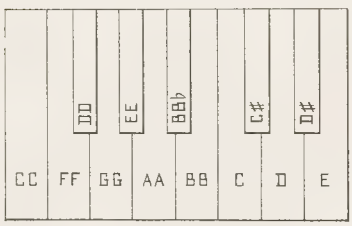


Fig. LXX.

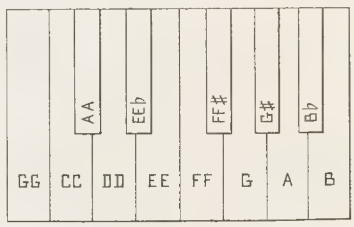


Fig. LXXI.

Another treatment obtained in English Organs, constructed in the eighteenth century, in which the claviers were carried down to GGG, $10\frac{2}{3}$ ft. The disposition of the keys, according to the old English tablature, is indicated in Fig. LXXI.

There is another arrangement of the bottom octave, known as the "broken octave," in which two notes are added to that shown in Fig. LXX. The disposition of the keys is given, in accordance with the old English tablature, in Fig. LXXII. The additional FF♯ and G♯ keys were short and were placed over the rear portions of the DD and EE keys.

In Italian Organs, the manual claviers which descended to CCC frequently had the lowest octave "short," by the omission of CCC♯ and DDD♯; and the remaining notes were arranged as indicated in Fig. LXXIII.

"By these contrivances", as Hiles remarks, "space and expense were saved; the Organs being then always tuned in the unequal temperament, where the remote keys cannot be used, and consequently the C sharp, D sharp, F sharp, and G sharp could be dispensed with."

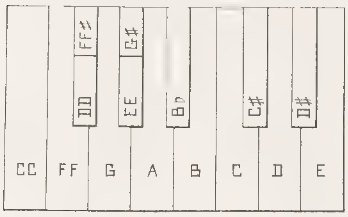


Fig. LXXII.

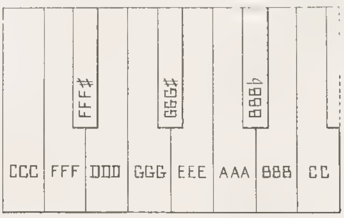


Fig. LXXIII.

Occasionally only a single note was omitted in the bottom octave, as in the Organ in the Church of St. Mary Magdalen, at Breslau, constructed by J. Röder in 1725. The manual claviers of this instrument extend from CCC to c^3, and are complete with the exception of the CCC♯ note. The above few particulars are sufficient even from the historical point of view; from a practical stand-point they are valueless. While the tuning in unequal temperament seems to have rendered the omission of certain bass notes advisable, the introduction of equal temperament rendered the adoption of the complete bass octave imperative. Short and incomplete octaves are, accordingly, curiosities of the past age of organ-building, interesting only to those versed in the history of the art.

We now come to the consideration of the compass of the Pedal Organ clavier. As in the case of the manual claviers, this has varied considerably in old times; having at first assumed several tentative forms, and later having been, to a large extent, controlled by the downward range of the manual claviers. Indeed, the desirability of making the downward limit of the pedal clavier agree with the downward limit of the manual claviers was very generally acknowledged, although there have been numerous departures from this arrangement.

It has been an almost universal practice in all countries where the manual claviers have been carried down to CC, to have the pedal clavier carried to the octave below; that is, to the note CCC, it being understood that there was in each case an independent Pedal Organ having a stop or stops of 16 ft. pitch. This arrangement allowed of the proper coupling of the manual claviers to the pedal keys. At the present day, the bottom limit of the pedal clavier is CCC; and so long as the bottom limit of the manual claviers remains at CC, no alteration can be logically or conveniently made. It is true that in some instances where the manual claviers descended to GGG, the pedal clavier had its bottom limit at CCC. This involved the necessity of coupling the manual claviers to the pedal clavier at the note CC, leaving the five notes of the manuals below it

uncoupled at all times. This was the case with the Organ in St. George's Hall, Liverpool, as originally constructed in 1855: its manual claviers had the compass GGG to a^3, while its pedal clavier had the usual compass of CCC to F. Two modes of coupling the manual claviers to the pedal keys were introduced in this instrument. In the first, the GGG key of the pedal clavier drew down the bottom key, GGG, of the manual claviers; the lower seven keys of the pedal clavier being uncoupled. In the second, the CCC or bottom key of the pedal clavier drew down the CC key of the manual claviers, leaving their five lower notes unaffected.

It was a common practice in England to introduce unison pedal claviers in Organs whose manual claviers descended to GGG, the lowest key of the pedal clavier being in such cases also GGG. The coupling, of course, was in such instruments direct and in unison. With the abandonment of the GGG downward range for the manual claviers all reason for the same downward limit for the pedal claviers disappeared.

Pedal claviers having FFF for their downward limit have occasionally been used. Notable instances occur in the Organs in the Royal Church of Saint-Denis; the Cathedrals of Milan, Antwerp, and Beauvais; and Chichester Cathedral, as constructed by Gray and Davison in 1844. The celebrated Organ in the Temple Church, London, had its pedal clavier of this bottom limit when left by Bishop in 1842. It was subsequently altered to the approved CCC limit. It is difficult to account for the adoption of this FFF downward range in such instruments as those in the Cathedrals of Antwerp and Beauvais, and the Church of Saint-Denis, save on the ground of insufficient space for the accommodation of the omitted large pipes, or of shortness of funds: the latter is improbable in the case of the Saint-Denis instrument. The difficulty obtains because all these Organs have their manual claviers carried down to CC. The same awkward system of coupling must exist in these instruments, as has been already mentioned in connection with the Organ in St. George's Hall, Liverpool; that is to say, the FFF key of the pedal clavier pulls down the FF key of the manual claviers, leaving their five lower keys unaffected. Of the other bottom limits, AAA and BBB, rarely introduced in the pedal clavier, it is unnecessary to speak. They are reported to have existed in the ancient Organ of Halberstadt Cathedral; and in one of the Organs in Seville Cathedral, built about the middle of the nineteenth century.

The upward limits that have been adopted for the pedal clavier have been numerous and cover a considerable range in the scale. In important existing Organs in Germany, Belgium, the Netherlands, Italy, Spain, and France, we find pedal claviers, with the CCC bottom limit, having all the following top limits: CC=13 notes; DD=15 notes; EE=17 notes; FF=18 notes; GG=20 notes; AA=22 notes; C=25 notes; D=27 notes; E=29 notes; and F=30 notes. In some instances, not necessary to be mentioned, these ranges have short or incomplete octaves, as in the manual claviers before described, which, of course, reduce the numbers of the notes above given. It may also be said that in isolated cases the pedal claviers commanded no special pipes, but merely drew down the lower keys of the manual claviers: in these cases the pedal claviers must have been in unison with the manuals so far as they extended.

In the three Organs already mentioned as having FFF for the bottom limit of their pedal claviers (the instruments in the Cathedrals of Beauvais and Antwerp, and the Royal Church of Saint-Denis), the top limit is in each case F, giving their Pedal Organs the compass of two octaves, or 25 notes.

In the old English Organs, whose manual claviers descended to GGG, the pedal claviers in nearly all instances had their bottom limit at the same note; while the following notes were adopted for the boundary of their upward ranges: FF=11 notes; GG=13 notes; C=18 notes; D=20 notes; and G=25 notes. And in later Organs whose pedal claviers were carried down to CCC, the following notes were adopted for their upward ranges: CC=13 notes; BB=24 notes; and C=25 notes. The above notes are according to our adopted tablature.

In what may be strictly called modern Organs, in which the downward limit of the pedal clavier is definitely fixed at CCC, we shall find a diversity of usage so far as its upward limit is concerned. This diversity obtains from D=27 notes to G=32 notes. The D upward limit is to be found in the Grand Organs in the Cathedrals of Senlis (Ouse) and Autun (Saone-et-Loire), and in the Choir Organ of the Cathedral of Notre-Dame, Paris, all of which were constructed by Merklin, of Paris. Walcker, of Ludwigsburg, has frequently used this top limit in important Organs; for instance, in the large Organs, in the Cathedrals of Riga (Russia), Ulm, and Vienna. It was also used by Cavaillé-Coll, as in his Grand Organ in the Church of the Madeleine, at Paris. The E upward limit has been comparatively seldom adopted by Continental builders; and only a few instances occur in English instruments. It was used by Willis, in 1847, in the Organ in Gloucester Cathedral; by Walker, in 1839, in the Organ in Exeter Hall, London; by Bishop, in 1852, in the Organ in the Church of St. James, Piccadilly, London; and by Gray and Davison, in 1855, in the Church of St. Luke, Old Street, London.

The favorite and most frequently adopted upward limit in modern Organs is the note F; and, indeed, it is so generally used at the present time, in England, France, and America, that it is quite unnecessary to name any examples.

The highest limit adopted up to the present time is G, which gives the pedal clavier the compass of 32 notes. The compass was used, in a complete form, as early as 1850, by Jackson, in the Organ in the Collegiate Institution, Liverpool. It now appears in the Concert Organs in St. George's Hall, Liverpool, and the Convention Hall, Kansas City, Mo.

It is quite certain that no lower limit than D should ever be used for new Organs, while there cannot be advanced any good argument for its adoption. While E is decidedly to be preferred, it need not be considered when a single additional inexpensive note places the Pedal Organ compass in its generally approved upward range. The F upward limit is perfectly satisfactory for Church Organs of all sizes; and need never be exceeded on any practical grounds. It is high enough for all legitimate organ music; and it gives the pedal clavier a width that is not too much for easy control.

Now that the G upward limit has appeared in two of the most important Concert-room Organs in the world, it is probable that it will in the future be considered, by advanced organists, as necessary in Organs of the first magnitude. It

is perhaps fortunate that the additional two upper notes will not prove a very expensive luxury; and, accordingly, their introduction in such instruments need not be discountenanced. Further particulars on this matter will be found in the Chapter on the Pedal Clavier.

CHAPTER XVIII.

THE SWELL IN THE ORGAN.

EVER since the time in which we first turned our attention to the art of organ-building, we have held the firm conviction that the importance of the swell in the Organ has been more or less misunderstood and neglected by those interested in the development of the "King of Instruments." Upwards of thirty years ago we worked out the problem of the swell in connection with the different divisions of the Organ to our own satisfaction; and up to the present day we have found no reason to modify the convictions then arrived at. We have, accordingly, strongly advocated a more liberal and systematic introduction of it than has been hitherto contemplated by conservative organ builders.* The following arguments in favor of the extended introduction of the swell in the Organ are substantially those presented in the Paper we had the opportunity of reading before the Royal College of Organists in the year 1889.

Before entering on artistic and practical matters it will not be out of place to briefly touch upon the history of the Swell, which opens in England. It is not

* "The chief advocate for the extended introduction of the swell-box in this country is Mr. G. A. Audsley, who has not only urged it on logical grounds in his treatise on 'Concert, Church, and Chamber Organs,' published in the columns of the *English Mechanic* (1886–8), and his recent lectures on the 'Swell in the Organ,' but has practically proved the great advantages to be secured by the multiplication of expressive departments in the Organ. About twenty-five years ago he schemed and constructed his own Chamber Organ, which was when finished, and still remains, for its size, the most flexible and expressive pipe organ existing. This can easily be understood when it is known that out of its nineteen speaking stops fifteen are rendered expressive by being inclosed in swell-boxes. The two expressive divisions of the Great Organ, on the lower clavier, are inclosed in two independent swell-boxes; the only stop here uninclosed being the PRINCIPALE GRANDE (*Open Diapason*, 8 ft.). The upper or Choir manual being entirely expressive. The range of expressive effects and *nuances* secured by these means is remarkable, while the tone qualities of the stops remain unaffected, and their balance is under perfect control. Mr. Audsley now advocates inclosing a portion of the Pedal Organ to make the bass also expressive"—Third Cantor Lecture on "Musical Instruments: their Construction and Capabilities," delivered before the Society of Arts, London, February 9, 1891, by A. J. Hipkins, F. S. A.

quite settled at what date the small division of the Organ known as the Echo was first introduced by English builders, but it seems certain that it was first used by them. In the description by Mace, in his "Musicks Monument," published in 1676, of his own Chamber Organ, we find the following particulars: "It is in Bulk and Height of a very Convenient, Handsom, and Compleat Table Seize; (which may Become and Adorn a Noble-Mans Dining Room) all of the Best sort of Wainscot. The Length of the leaf 7 foot and 5 inches; the breadth 4 foot and 3 inches; the Height 3 Foot, Inch, and Better. . . . The Leaf has in it 8 Desks, cut quite through very neatly, with Springs under the Edge of the Leaf, so contriv'd that they may Open and Shut at pleasure; which (when shut down) Joyn closely with the Table-Leaf; But (upon occasion) may be Opened and so set up (with a spring) in the manner of a Desk, as your Books may be set against Them. Now the Intent of Those Desks, is of far more Excellent use than for mere Desks; For without those Openings your Organ would be but of very slender use, as to Consort, by Reason of the Closeness of the Leaf; but by the help of them, each Desk opened, is as the putting in of another quickning or enliv'ning stop; so that, when all the 8 Desks stand open, the Table is like a Little Church Organ, so sprightfully lusty, and strong, that it is too loud for any ordinary private use; but you may moderate that, by opening only so many of those Desks as you may see fit for your present use. There are in this Table Six Stops, the first is an Open Diapason; the second, a Principal; the third, a Fifteenth; the fourth, a Twelfth; the fifth, a Two-and-Twentieth; and the sixth, a Regal. There is likewise (for a pleasure and light content) a Hooboy Stop, which comes in at any time with the foot; which stop (together with the Regal) makes the Voice Humane."

Now, although this highly interesting description appears in Dr. Rimbault's "History of the Organ," and accordingly has been under the notice of the organ-loving world for nearly half a century, we do not remember ever having seen it commented upon. Let us see if it is not worthy of a little study. Only extracts have been given from Master Mace's full description of this "Table Organ," which the writer claims as his own contrivance. He adds: "Two of such organs only are but as yet in Being in the World; They being of my own contrivance; and which I caus'd to be made in my own House, and for my own Use, as to the maintaining of Public Consorts, &c." In giving this description the consideration it deserves, one cannot avoid recognizing that Mace's instrument was the true starting point of the Swell Organ; and, with such an instrument before their eyes, it is a surprising thing that the organ builders of the time did not catch the idea of the swell. We are told by Mace that the "Leaf," or top of his "Table Organ," had eight desks, which were so fitted as to be almost invisible when closed down, but which could be raised up and fixed open with springs, leaving openings in the leaf through which the sound from the pipe-work, inclosed in the body of the instrument, found egress. He tells us that these desks were "of far more Excellent use than for mere Desks; For without those Openings, your Organ would be but of very slender use, as to Consort, by Reason of the Closeness of the Leaf." In closing all the "desks," it stands to reason that the entire instrument became so subdued as to be an Echo Organ. "By the help of them,"

as Mace quaintly remarks, "each Desk opened, is as the putting in of another quickning, or enliv'ning stop; so that, when all the 8 Desks stand open, the Table is like a Little Church Organ, so sprightfully lusty, and strong, that it is too loud for any ordinary private use; but you may moderate that," says this pioneer in artistic organ-building, "by opening only so many of those Desks as you see fit for your present use."

Master Mace, as he wrote those words, or surveyed, with feelings of pride, his curious and noteworthy "Table Organ," was standing on the threshold of a great discovery or invention. Had he abandoned the practice of opening and shutting those eight "Desks" by hand, and simply connected them by a system of levers to a single pedal, or foot-lever, he would have invented the true swell, and, at one step, have imparted powers of flexibility and expression to the Organ. Such an oversight—to call it by no harder name—seems to us, in this inventive age, almost impossible, and certainly unpardonable. There was the swell forcing itself on his observation every time he opened or closed one, two, three, or more of the desks to apportion the sound of the instrument to the requirements of the "Consort." It is self-evident that the organ builders of the year of grace 1676 were just as slow of comprehension, and as adverse to radical departures from established custom, as are the organ builders of to-day. But however this may be, it took nearly a century to carry the idea that lay hidden, in broad daylight, in Mace's movable desks and table top into anything like practical form. It seems quite probable that at the date Mace constructed his notable Chamber Organs, the closed division of the Church Organ, called the Echo, had been introduced; but, at the same time, it is quite evident that no such division existed in the Organ built by Robert Dallam, of London, in the year 1634, for the Cathedral of York. This land-mark in the history of English organ-building had only two divisions; namely, a Great Organ and a "Chair," or Choir Organ. The Echo was probably not known at so early a date. We need not dwell on the subject of the Echo Organ, as, beyond its being the precursor of the Swell Organ, it has little interest here. We shall accordingly pass on to the year 1712. Among the advertisements in the *Spectator*, issued on February 8, 1712, the following interesting announcement occurs:

"Whereas Mr. Abraham Jordan, senior and junior, have, with their own hands, joynery excepted, made and erected a very large Organ in St. Magnus' Church, at the foot of London Bridge, consisting of four sets of keys, one of which is adapted to the art of emitting sounds by swelling the notes, *which never was in any Organ before;* this instrument will be publicly opened on Sunday next, the performance by Mr. John Robinson. The above-said Abraham Jordan gives notice to all masters and performers, that he will attend every day next week at the said church, to accommodate all those gentlemen who shall have a curiosity to hear it."

This announcement fixes two facts practically beyond question; namely, that the invention of the Swell is due to Englishmen, and that its first introduction in an Organ took place, in London, in the year 1712. The invention, as introduced by the Jordans, consisted of a front to the old echo-box, fitted with a sliding

shutter, which was raised and lowered, at the will of the player, by means of a foot-lever. On depressing the lever the shutter was raised, the box opened, and the sound from the inclosed pipe-work permitted to issue forth more or less freely. On relieving the pressure on the lever the shutter fell and gradually closed the box. As Dr. Hopkins correctly remarks: "The '*nag's-head swell*,' as the above early kind of swell was called, was not well designed, nor happily adapted to its purpose in a mechanical point of view. The weight or resistance to be overcome by the pressure of the foot was so great that the shutter could be set in motion only with difficulty, and when it was in motion there was equal difficulty in regulating the rate or extent of its ascent; for it would then not unfrequently run up almost of itself. Its descent was similarly beyond control, and it would often fall with an audible noise. The nag's-head swell continued in use for upwards of half a century, till it was superseded by what has since been denominated the 'Venetian swell.'"

Professor Dudley Buck, who quotes Jordan's advertisement in his interesting Lecture on "The Influence of the Organ in History," remarks: "Very little is known of this Mr. Jordan, except that his invention pleased greatly, and was found of such practical use, that not only were all new Organs in England (virtually from this date) furnished with swells, but himself and son found much occupation in adapting and adding their invention to the older London Organs. The lack of a swell is the weakest point of the great majority of German Organs. Even Dr. Burney, fifty years after swells had become common in England, expresses, in his famous work entitled 'Continental Tours,' his great surprise to find them utterly unknown upon the Continent. His remarks would hold true at the present day [1882] with but little modification, so far as Germany is concerned, but few instruments, outside the larger ones of recent date, possessing this great improvement. The reason of this is to be found partly in the extremely conservative character of their organ builders, almost a national trait, and still more in the fact that but little use would be found for a Swell Organ outside solo playing. With us," concludes the able Professor, "nearly the reverse is true, the Swell being most indispensable in accompanying choirs as here constituted."

Passing on to the year 1738, we find not only that the swell has become (even in its primitive form) firmly established in England, but that it is described in glowing terms. In the Articles of Agreement entered into by John Harris, organ builder, of London, for the construction of an Organ for the Parish Church of Doncaster, the following passage occurs relative to the Swell Organ:

"The Eccho Organ to contain the following Stops, which shall Eccho and Swell to express passion in degress of Loudness and Softness, as if inspired by human breath (viz.) One open Diapason with twenty-seven Speaking pipes. One stop'd Diapason with twenty-seven pipes. One Principall with twenty-seven pipes. One Cornet of three Rows with eighty-one pipes. One Trumpet and one Hautboy with twenty-seven pipes to each. . . . The keys of the Ecchos and Swelling from C sol fa ut Cliff, to D la sol, in all being twenty-seven keys."

At this time the so-called "nag's-head swell" continued in use, and had only a very limited compass; namely from middle c^1 to d^3, or thereabout. In the year

1769, Burkat Shudi, a maker of Harpsichords, took out a patent for "A piece of mechanism or machinery by which the Harpsichord is very much improved." In his Specification he thus describes his invention: "A cover extending the breadth of the Harpsichord, and from the front board of the Harpsichord to the ruler, of an indefinite number of valves, which, with their frame, extend the breadth of the Harpsichord, and the length thereof from the ruler to the small end, which valves are opened and shut by a number of small levers equal to the number of valves inserted or fixed in an axis spindle or bar turned by a pedal." It is to be understood by this description that the instrument, instead of having a single solid top or cover, as we see in Handel's Harpsichord, preserved in South Kensington Museum, and in all the German Harpsichords, was furnished with an inner cover, formed of narrow pieces of wood suspended by centre-pins in a frame of the size and shape of the stringed portion, and made so as to open and shut all together by means of a series of small levers controlled by a foot-lever or pedal. When closed the cover presented a level surface, and the sound from the strings was very subdued; and, of course, when the pedal was depressed by the foot of the performer, and the narrow pieces of wood (about 3 inches wide), or the shutters, turned, more or less, on their centres so as to leave openings between their edges, the sound swelled forth. It will be observed that Shudi's invention was really shadowed forth in Mace's Chamber Organ, with its table-top and eight lifting desks or shutters. Only, as has been explained, these desks had to be raised or opened singly by hand, and were not under the direct control of the performer at the keys. These facts show how slowly ideas develop; for it was about thirty-six years after Mace's invention for controlling the sound of his Organs, that Jordan invented the nag's-head swell; and it took another long period of fifty-seven years before any appliance was introduced which pointed the way to the improvement of the Organ swell-box. Shudi's invention was the precursor of the mechanical and effect-producing portion of the Swell Organ as we now have it.

The honor of having applied Shudi's system of moving shutters to the Organ swell-box is accredited to Samuel Green, of London: and the swell as constructed by him was termed the "Venetian swell," probably on account of its resemblance to a Venetian blind or shutter. All who believe in the great importance of the swell in the Organ should hold Green's name in high respect; for, apart from his ingenious adaptation, he developed the entire department considerably beyond the limits adhered to by his predecessors. Indeed, he may justly be called the Father of the Swell Organ in its approved treatment. In the instrument he built for the Chapel of Greenwich Hospital, he carried the Swell Organ down to FF, only five notes short of its present full compass downward. This instrument was built in 1789. In the following year he constructed his notable Organ for St. George's Chapel, Windsor, inclosing even the Great Organ in a large swell-box. We cannot, in honoring the name of this great English organ builder, help wishing that there were some Samuel Greens among us now, for it would be well for the art we love. They were by no means small steps for any one man to take, in the first place, from the half-stop, nag's-head swell, with all its shortcomings and imperfections, to the practically perfect Venetian swell of almost the full

compass approved to-day; and, in the second place, onward to the bold experiment of inclosing the Great Organ stops in a swell-box.

We now enter the nineteenth century, and may pass over its first half with the general remark that it saw no further development of the swell than had been achieved by Green in his ordinary instruments. In the year 1855, the large Concert-room Organ was erected by Henry Willis in St. George's Hall, Liverpool. This most important instrument, although remarkable for the great compass of all its four manual divisions and the grandeur of its tonal resources, was furnished with only one *expressive* division –the Swell Organ. This contained twenty-five speaking stops, and was, unquestionably, a fine and most effective division. As it is certainly due to this Organ that we are in the position to write the present treatise, we may be pardoned in dwelling upon it to some length. Between the years 1856 and 1884 it was our privilege to listen to this magnificent instrument weekly—very frequently three times a week—played by probably the greatest master of the Organ who lived in the nineteenth century. During these twenty-eight years we had every opportunity of realizing all that the Organ and its master were capable of: and it will be admitted that we had the best possible means of discovering both the strong and the weak points of the instrument. On its strong points—so well known to all students of organ-building—it is unnecessary to touch; but on its chief weakness we have to pass a few remarks. This weakness may be summed up in a few words—deficiency in powers of flexibility and expression. The expressive powers of its truly fine Swell Organ were, of course, highly satisfactory, so much so that one could not avoid regretting that similar powers had not been bestowed upon other divisions of the instrument. It was not long after first hearing the St. George's Hall Organ, that the weakness alluded to became evident to our musical sense. We soon discovered that its weakness lay in its *strength*,—in its strength or intensity of tone,—which could not be regulated at will without manipulating the stops; a mode of regulation quite distinct from that understood in the term expressive power. Manipulation of the speaking stops gives tonal coloring; whilst the use of the swell gives degrees of power, flexibility, and expression to such tonal effects. As we shall say a good deal on the subject of the swell and its application to the several divisions of the Organ later on, we shall now consider the manner in which the performer was handicapped in performing on such an instrument as that alluded to. He had an immense Organ under the control of his hands and feet; namely, four manual divisions, comprising eighty-three speaking stops, having a compass from GGG to a^3=five octaves and two keys; and a pedal department of seventeen stops; yet of all these speaking stops only twenty-five were capable of expression, in the sense the term is used here. The whole of the fine series of stops in the Solo Organ, comprising nine powerful reeds, and such solo stops as the TROMBA, CLARINET, and ORCHESTRAL OBOE in the Choir Organ, and all the assertive reeds in the Great Organ, were absolutely beyond the effects of light and shade; and, accordingly, had to be used at one unvarying strength of tone from one year's end to another. Surely no one with anything like a refined ear or a sense of musical propriety, can question the absurdity of leaving without powers of flexibility and expression such stops as the

Clarinet, Orchestral Oboe, and such powerful reeds as the Solo Tromba, Ophicleide, Cornopean, and Trompette Harmonique, which speak, with almost overwhelming power, on wind ranging in pressure up to twenty-two inches. Any one who disputes the advantage of giving powers of expression to such demonstrative solo stops has a musical sense in inverse ratio to his love of blatant noise —a love only too evident in the majority of organ builders and organists.

After being an attentive listener to the Organ in question for a lengthened period; and having carefully observed its tonal effects and its manipulation under the masterly touch of the late Mr. W. T. Best, we came to the conclusion that, notwithstanding its immense tonal resources, it was sadly deficient in flexibility and powers of expression. The more we thought of the matter, and the more closely we analysed the methods followed by the talented organist, the firmer became the conviction that the Organ *per se* is inherently, under its usual construction and appointment, an expressionless instrument. This conviction, arrived at about the year 1860, induced us to take up the study of organ construction.*

For many years after the construction of the Liverpool Organ, English instruments continued, with one notable exception, to be schemed with only one expressive division, called the Swell Organ. This notable exception is the Concert Organ erected in the Town Hall of Leeds, in the year 1859, from the Specification prepared by Henry Smart and Dr. Spark. In this instrument two expressive divisions are introduced; namely, the Swell Organ, of twenty stops, and the Solo Organ, of eight stops, the ninth stop—the Ophicleide—being (unwisely) placed outside the swell-box. In this instrument there are accordingly twenty-eight stops under control and expressive out of a total of seventy-seven manual stops. We may pass over all the other Organs made prior to the year 1873; but in that year a Concert Organ was erected in the Albert Hall, at Sheffield, which deserves special notice in this hasty survey. While we naturally regret that this typical instrument is not the work of an English builder, we are glad it stands a monument to the genius of our late esteemed friend, M. A. Cavaillé-Coll, of Paris. In this Organ decided steps are made toward rendering the instrument fully expressive: and, up to the present hour, we are not aware of any large Organ having been constructed in Europe which goes beyond it in this direction. Perhaps the comparatively small Accompanimental Organ, by the same distinguished builder, in the Carmelite Church, Kensington, London, may, from a certain point of view, be considered more expressive.

In the manual divisions of the Sheffield Organ there are fifty-two speaking stops; and of this number no fewer than thirty-three are rendered flexible and expressive by being inclosed in three separate swell-boxes. The disposition is as follows: The Grand-Orgue, of sixteen stops, is exposed and unexpressive; the Positif, of twelve stops, is inclosed in a special swell-box, and is entirely expressive; the Récit, of twelve stops, is inclosed in a second swell-box, and is also entirely expressive; and the Solo, of twelve stops, is mainly expressive by having

* We have spoken of the Liverpool Organ in the past tense because it has recently been reconstructed, with some slight additional powers of expression. See Specifications.

nine of its stops inclosed in a third swell-box. From these facts it can be seen that the flexibility and expressive powers of this instrument are considerable.

In the year 1877, another noteworthy Organ was erected in the Concert-room of the Public Halls, at Glasgow, by T. C. Lewis & Co., of London, from the Specification and under the direction of the late W. T. Best and Henry Smart. In the four manual divisions there are fifty-two speaking stops; and of these twenty-six are rendered expressive by being inclosed in swell-boxes. The disposition of the tonal forces in this Organ are as follows: The Great Organ, of eighteen speaking stops, is entirely exposed and is accordingly unexpressive; the Swell Organ, of seventeen stops, is inclosed and entirely expressive; the Choir Organ has ten stops, two of which—the CLARINET and VOX HUMANA—are inclosed in a special swell-box and rendered expressive; and the Solo Organ, of seven stops, is inclosed in an independent swell-box and is entirely expressive.

With reference to the great advantages, from the true musician's point of view, derived from even the limited powers of expression provided in the Glasgow Organ, the opinion may be recorded here of a master whose right to speak with authority on matters of musical expression no one will venture to question. Dr. Hans von Bülow says, in the *Glasgow Herald* of November 3, 1877:

"I never met with an Organ so good in Germany, the instruments there not having the same amount of expression and flexibility—most delicate and exquisite *nuances*—that hearing the *diminuendi* and *crescendi* was to me a new sensation. If I would longer listen to an Organ like this, and a player like Mr. Best, I would, were I not grown too old, jeopardise my pianistical career, and begin to study the Organ, where certainly I would be able to display much more eloquence as Beethoven's and Chopin's speaker. In short, despite having been exceptionally fatigued by your consecutive concerts and numerous rehearsals, I listened with the most eager attention from the first to the last note of Mr. Best's recital."

Surely no higher testimony than this can be required as to the great value of increased powers of expression by the only means available in the Grand Organ: and yet we hear men who can just struggle through a piece of organ music in a mechanical manner, and organ builders who can just manage to put an Organ together on the stereotyped lines, condemn, in terms as emphatic as they are redolent of ignorance, the practice of introducing the swell in more than one division of the Organ.

The largest Organ ever constructed in England is that which now stands in the Town Hall of Sydney, N. S. W., which contains one hundred and twenty-six speaking stops. Notwithstanding its immense size and the recent date of its construction, this Organ presents not a single step in advance in the science and art of organ-building: in the matters of flexibility and expression it is behind and inferior to the Leeds Town Hall Organ, built about thirty years before; is only slightly in advance of the Organ in St. George's Hall, Liverpool, as built in 1855; and is immensely inferior to the Sheffield and Glasgow Organs, built, respectively, in 1873 and 1877. The Sydney Organ contains in its five manual divisions the great number of one hundred speaking stops, out of which only twenty-nine are expressive. In addition to the Swell Organ proper, the five reeds of the Choir

Organ are inclosed in a separate swell-box. The mistake of leaving the Solo Organ, of twenty stops, including nine reeds, without powers of expression is altogether unpardonable, especially as the original Specification, issued by the Town Council of Sydney, calls for the Solo Organ, of twenty stops, to be inclosed in a swell-box. Indeed, so strictly commonplace is the entire scheme of the instrument as constructed, that one can understand the late Mr. W. T. Best's stricture on the specification of what he facetiously called "the Megatherium destined for Kangaroo-land," when he speaks, in a letter to us, of the builder "merely serving up six ordinary Church Organs in the same Church House." The vast difference between the scheme as carried out and the scheme of another competing firm for the same instrument will be shown later on.

Leaving English and French organ-building for the present, we may direct attention to the work done and the views held by the distinguished American organ builders, the late Messrs. Roosevelt, of New York. Respecting works executed, two examples may be taken—one a Church and the other a Concert Organ.

In the year 1883, there was erected in the First Congregational Church, at Great Barrington, Mass., an Organ containing in its three manual divisions (exclusive of the Echo Organ of five stops) forty-eight speaking stops, of which no fewer than thirty-eight are expressive and under perfect control as regards strength of tone. The disposition is as follows: The Great Organ, of seventeen stops, has seven stops inclosed, and accordingly is partly expressive; the Swell Organ, of eighteen stops, is inclosed and entirely expressive; and the Choir Organ, of thirteen stops, is inclosed in a separate swell-box and is entirely expressive.

Turning now to the most important Concert Organ constructed by Mr. Roosevelt—that in the Auditorium, at Chicago—we find the greatest development achieved by him in the direction of flexibility and expression. This large instrument has distributed throughout its five manual divisions (exclusive of the Stage Organ) eighty-six sounding stops, of which the large number of seventy-nine are inclosed in five separate swell-boxes, and rendered flexible and expressive. The disposition of the tonal forces is instructive and highly interesting. The Great Organ, of twenty stops, has thirteen of them inclosed in swell-box No. 1, and is accordingly about two-thirds expressive; the Swell Organ, of twenty-three stops, is inclosed in swell-box No. 2, and is entirely expressive; the Choir Organ, of seventeen stops, is inclosed in swell-box No. 3, and is entirely expressive; the Solo Organ, of fifteen stops, is inclosed in swell-box No. 4, and is entirely expressive; and the Echo Organ, of eleven stops, is also inclosed in a swell-box, No. 5, and is entirely expressive. Three balanced expression-levers control the five swells; one controls the Great and Choir, one the Swell proper, and one the Solo and Echo.

In proof of Mr. Roosevelt's firm views in relation to artistic organ-building, we make public, for the first time, his notable scheme, submitted in competition, for the Town Hall Organ, at Sydney; and unfortunately passed over by the authorities, probably because it was too advanced and too artistic to be understood by them. Be this as it may, it would certainly be difficult to bring forward a more decided contrast to the commonplace scheme of the executed instrument.

First, as a brief summary, it may be pointed out that, according to Mr. Roosevelt's scheme, the Organ was designed to contain one hundred and thirty speaking stops, distributed over the six independent divisions. In the five manual divisions are one hundred and four stops, of which no fewer than ninety-three are rendered expressive and flexible (more than three times the number of expressive stops in the executed instrument) by being inclosed in four immense and independent swell-boxes. Further to establish complete command over the vast tonal forces—comprising five stops of 32 ft. pitch; twenty-one of 16 ft.; fifty-six of 8 ft.; twenty-five of 4 ft.; six of 2 ft.; seven mutation stops of various pitches; and forty-four harmonic-corroborating ranks—there are seventeen couplers, four tremolants, three balanced expression-levers, a lever producing a stop *crescendo* and *diminuendo* on the entire Organ, and a complete "Roosevelt Patent Adjustable Combination Action," commanded by thirty-seven thumb-pistons and eight foot-levers. No organ scheme previously devised can for one instant be compared with this in matters of expression, flexibility, easy control, and mechanical accessories.

The general disposition of the stops is as follows: The Great Organ contains twenty-eight speaking stops, of which seventeen are rendered expressive by being inclosed in swell-box No. 1, which also holds the Choir stops; the Choir Organ, of nineteen stops, is entirely expressive; the Swell Organ contains thirty stops, inclosed in swell-box No. 2, and is entirely expressive; the Solo Organ contains seventeen stops, inclosed in swell-box No. 3, and is entirely expressive; and the Echo Organ, of ten stops, is also entirely expressive. The Pedal Organ contains twenty-six stops, none of which are expressive or under control as regards strength of tone: and here we take serious exception to the scheme, in common with the schemes of all the Organs previously alluded to, for reasons shortly to be given.

We may properly conclude this branch of our subject by directing attention to the largest and most remarkable instrument in existence at the present time; namely, the Concert Organ constructed by The American Art Organ Company, of Los Angeles, Cal., for the immense Convention Hall, Kansas City, Mo. So far as its manual divisions are concerned, this Organ presents what may be safely considered to be the highest practical development in the direction of flexibility and powers of compound expression. Although a full description of this grand Organ is given in the concluding part of the present volume, we may properly give here an outline of its swell appointment.

The Organ contains in its seven manual divisions and subdivisions one hundred and ten speaking stops, of which no fewer than ninety-seven are rendered flexible and expressive. The general disposition of the stops is as follows: The Great Organ contains twenty-six stops, of which thirteen are inclosed in swell-box No. 1; the Choir Organ contains twenty stops, all inclosed in swell-box No. 1; the first subdivision of the Swell Organ contains twenty-three stops, inclosed in swell-box No. 2; the second subdivision of the Swell Organ contains eleven stops, inclosed in swell-box No. 3; the Solo Organ contains eighteen stops, inclosed in swell-box No. 4; and the Echo Organ contains twelve stops, inclosed in swell-box No. 5. All the swells are controlled by separate balanced expression-levers; while

foot-levers are provided for opening and closing all the swell-boxes simultaneously. Here, again, conservative methods of organ-building have prevented the Pedal Organ from being properly furnished with flexibility and direct powers of expression; and all that is possible in this direction is attained by borrowing three stops from expressive manual divisions. We greatly regret that our strong advice in this important matter was overruled by persistent conservatism; otherwise the pedal department of this great instrument would have possessed a flexible and expressive subdivision of fifteen stops, including the eight reed stops, the imitative string-toned stops, and the harmonic-corroborating work.

A few arguments may now be advanced in favor of an extended introduction of the swell in the Organ.

There has been and still is in certain quarters a firm belief that the swell-box is destructive to the sounds of the inclosed pipe-work; and we are free to admit that this belief has had in too many cases a good foundation; but a foundation that is anything but creditable to organ builders on the one hand, and to the reasoning powers of those outside the organ-building trade on the other. Whilst the former, in these days of cheap and competitive organ-building, very rarely care, or can afford, to show the spirit of artists or pioneers in the direction of radical improvements, the latter seem to overlook the fact that there are good as well as bad swell-boxes, and supinely accept just what the economically-disposed organ builders think proper to give them. We frequently wonder if it ever occurs to interested purchasers of Organs that a good, and properly-designed and proportioned swell-box costs considerably more than one of the cramped and unscientifically-constructed things which are, as a rule, introduced in Organs built on the competitive system, almost universally (and most unwisely) followed at the present time.

Perhaps it is unreasonable to condemn those who, although admirable performers on the imperfect instruments served out to them, have a very superficial knowledge of the true principles of construction and of the internal economy of the Organ generally; and especially as some persons who claim to be practical authorities on organ-building hold that *small* swell-boxes—just sufficient to contain the closely packed pipe-work and no more, with sloping roofs to do away with all *unoccupied space* inside, not to speak of the desirable *economy of wood*—are the most satisfactory. It is difficult to imagine upon what these worthies base such a belief, except it be on dollars and cents, for it is entirely unsupported by scientific teaching and common sense.

There is, of course, no question that stops inclosed in swell-boxes undergo a certain modification in their tones; but it is also a fact (and here we speak of what we know) that when the swell-boxes are properly proportioned and constructed, and the stops correctly spaced, and skilfully voiced for their position, the slight modification is an improvement rather than the reverse, giving a further refinement to their tones. Of course, to organists who love noise in organ music in preference to every other quality; and who are never truly happy save when they have every available stop of their instruments drawn, every coupler on, and the swells fixed open to their full extent, such refinement is simply so much power

lost, so much possibility for noisy and ear-splitting effects done away with. Such robust players hold up their hands as if to ward off some dire calamity when the inclosing of the TUBAS and other powerfully voiced reed stops is advocated. "What!" say they, "spoil our most effective stops by putting them in a swell-box? The powers forbid! Where would our grand climaxes, our immense effects, and our overwhelming crashes be?"

Well, we have no delight in such robust playing, to use a mild expression; and we do not believe that it is musicianly or artistic. Accordingly, we are resolved to advocate and support any legitimate means of discouraging such outrage on the musical ear—that is, if it can be discouraged. It must be said, however, that even the fullest possible introduction of swells in the Organ can only counteract such ear-splitting effects to an extremely limited degree, so long as the taste for stops voiced on excessive pressures of wind are favored by organ builders and organists —we use the term organists, for we can hardly think the true and refined *musician* can favor such things, especially in their usual uncontrollable condition. Surely anything and everything conducive to refinement and flexibility of tone in our monster modern Organs should be hailed with delight by both players and listeners.

In approaching the practical aspect of matters connected with the formation of swell-boxes, it is desirable that, as musicians, we should arrive at some sort of logical conclusion on two points. First, what the tone of the inclosed stops should be when the swell-box is fully opened; and, Secondly, what the tone should be, relatively, when the box is completely closed. Or, in fewer words, what degree of *diminuendo* is necessary or desirable in any expressive division of the Organ. To settle this question from a purely musical standpoint, it would be well to put the influence of any Organs we are familiar with out of our minds, and seek elsewhere for inspiration and guidance.

In considering this important question respecting the desirable degree of reduction in tone, or *diminuendo*, in an organ swell, we must suppose the full contents of the swell drawn; for the reduction of tonal power by the manipulation of the stops is altogether another matter, and need not enter the question at all.

In this matter we shall be best helped by turning our attention to the Orchestra. Let us imagine a selection of the different orchestral instruments made, say ten or fifteen, of different tones and pitches, and sounded together in unison or harmony at what may be considered their *fortissimo*, or at the fullest strength possible without impairing their pure normal qualities of tone; and let us accept the full volume of sound so produced as representing the tonal effect of all the stops forming an expressive division, with the swell-box open to its full extent. Now, let us request the instrumentalists to perform a gradual *diminuendo* until they reach the *pianissimo*, or the softest tone consistent with the pure musical character of their respective instruments; and let us carefully record the result in our musical consciousness. When this *pianissimo* is reached we shall hear a comparatively soft effect in relation to the preceding loud one; but we shall still hear a full, rich, and perfect volume of pure tone, without any indication of that smothered, "bee-in-a-bottle," mile-away, emasculated kind of tone, which is gen-

erally accepted as the acme of the organ builder's skill in swell-box construction. We have listened to closed swells which entirely destroyed the true and characteristic tones of the inclosed pipe-work; and we unhesitatingly condemn such swells as gross libels on scientific and artistic organ-building—the work of bunglers, and the natural mistakes of men who have blindly followed precedent, or who have, from first to last, misconceived the true use and value of the swell in the Organ.

The swell, when properly constructed, is a legitimate means, within reasonable limits, for securing two most desirable objects; namely, *flexibility* and *musical expression.* To exceed those reasonable limits, is to be guilty of a serious mistake, and to call forth a deserved condemnation from every true musician. We speak strongly because we feel strongly in this matter: and no one who loves the Organ as we do, and who knows what it is capable of becoming under thoughtful and artistic treatment, can help regretting and lamenting whilst he sees hundreds of thousands of dollars thoughtlessly expended every year on Organs without a single serious attempt being made to render them more *truly musical*, *flexible*, and *expressive.*

It will be realized from what has been said that we advocate so constructing the swell-box, of any division of the Organ, that when it is closed it shall not destroy, or even impair the tonal character of the inclosed pipe-work. The listener should at all times hear distinctly the true tones of the stops that are speaking. Further than this, we hold that the effect of the closed swell should not be a *distant* one, any more than the *pianissimo* of the Orchestra should produce that effect; but that it should be merely a *soft* and *pure* one—one that can be prolonged through an entire movement, if necessary, without producing an unsatisfactory impression in the player's or the listener's mind.

We know it is the common impression among organ builders and organists, that unless the closed swell has a very *distant*, or what we should call a *bottled-up* effect, no satisfactory *crescendo* can be obtained; but we have practically tested this matter; and are satisfied that a full and perfect *crescendo* and *diminuendo* can be secured from a swell constructed on the lines we advocate. Apart from its proper construction, two conditions are essential to its success; namely, ample internal dimensions, and a proper position for the free egress of sound.

Considerable objection has been raised against the extended introduction of the swell through the unskilful and unmusicianly way too many organists have used and still use it. What is commonly called "pumping the swell-pedal," or what, in more polite language, may be termed the restless, sentimental method of using the swell, is most objectionable from every point of view, and young players are specially fond of it. It rarely occurs to them that the swell has another office than that of producing an everlasting *crescendo* and *diminuendo.* We are of opinion that the form of swell-pedal, or expression-lever, as we prefer to call it, commonly introduced in English Organs, has greatly tended to foster the restless or sentimental style of swelling above spoken of. We allude to the ordinary recovering, or so-called "hitch-down pedal," so undeservedly popular with old-fashioned English organists. We know that the Royal College of Organists has advocated this form in its conservative way; but we venture to disagree with its advocacy in

this, as in certain other matters of organ-building,—doubtless, a very presumptuous thing to do.

We may state here that the old-fashioned "hitch-down pedal" cannot be used where the swell is fully developed and its proper functions are provided for. Some appliances have been introduced by English builders with the view of doing away with the inherent imperfections of the "hitch-down pedal," and for the purpose of enabling the performer to leave the pedal stationary at certain points of its downward or upward range; and such appliances clearly point to the inherent shortcomings of the said pedal, which they only partly remove. Conservative organists hesitate to approve of the self-evident advantages offered by such appliances. The correct, common-sense, and convenient form of expression-lever is that known as the "French," or "balanced-pedal;" and this is the form which will alone be used in Organs constructed on the proper lines. It is already used, almost exclusively, by the leading builders of America and the Continent of Europe; and is advocated by all the distinguished organists of France and the United States.

We may now enter upon the consideration of the swell as applied to each separate division of the Organ. In doing so we shall touch upon all the offices of the swell, and point out its practical conditions and requirements at the same time. We have no intention of touching, in the present Chapter, on the tonal structure of the Organ, or of specially commenting on the somewhat complicated question of the proper disposition or appointment of the tonal forces in the several divisions of the instrument: these important matters are fully treated in other Chapters. We shall, accordingly, speak of the application of the swell to the several divisions of the Organ without special reference to the inclosed speaking stops. So when we speak of the Great Organ, Choir Organ, Swell Organ, Solo Organ, and Pedal Organ, no reference will be made to any new or unusual stop appointment. For the sake of convenience, the reader may look upon these divisions of the Organ as differing in no essential point from those found in the best examples of European and American organ-building.

Whilst we do not anticipate a storm of opposition to the proposal to extend the application of the swell-box to such divisions of the Organ as the Choir and Solo, we are prepared to meet with a whirlwind of objections—unreasonable and illogical for the most part—against the proposal we have to urge to apply the swell-box to both the Great and Pedal Organs. But this whirlwind will not blow us away from the stand long study has induced us to take in so important a question; and we do not fear that we shall long remain unsupported by thinking musicians. To the ordinary organist the idea of inclosing any portion of the Great Organ in a swell-box, and thereby imparting to its tonal forces flexibility and expression, smacks of musical heresy, if it does not seem to him absolute absurdity. We shall see how far the charge of heresy or absurdity can stand under the light of sound reasoning and common sense. At this point we make a simple statement, which may be new to the reader, but which we recommend to his serious consideration. It is this:

There is no more reason in making any division of the Organ unexpressive

and invariably uniform in the strength of its tones, than there would be in destining any division of the Grand Orchestra to deliver its sounds at one unvarying strength and without any expression whatever.

To our mind this statement contains a perfectly logical proposition; and surely every thoughtful and unprejudiced musician must recognize it the instant its true bearing enters his mind. In a conversation we had some years ago with Dr. E. H. Turpin, the amiable and talented Honorary Secretary of the Royal College of Organists, immediately after an admirable lecture he had delivered on the "Instruments of the Modern Orchestra," he made the following highly suggestive and apt remark: "The Grand Orchestra may be considered as the Sun in the musical universe, whilst the Grand Organ may be looked upon as the Moon, shining with *borrowed light.*" How we wish both organ builders and organists would realize what this terse remark really means; and how much its acceptance and its logical teaching would benefit the art of organ-building.

In applying the swell to the Great Organ, it is with the view of making it flexible rather than for the purpose of imparting powers of expression to it. Only a very few stops suitable for this division call for expressive powers. We have used the terms *flexible* and *expressive* frequently in the foregoing remarks; and it is perhaps desirable that we should clearly define their meaning, and the distinction to be drawn between them so far as the Organ is concerned. When we speak of an Organ being *flexible*, we desire to convey the idea that it is capable of immediate and easy control, so far as the strength of tone of any division, or portion of any division, is concerned, at the will of the player. Under the present crude system of organ-building and tonal apportionment, numerous stops are inserted which have a sharply defined and a very restricted use. Take all the harmonic-corroborating stops, and it will be found, under the present stereotyped system, that they are usable only in full effects, or when all the foundation-work is drawn. For instance a Great Organ MIXTURE would be drawn when or after all the stops below it in the harmonic structure are drawn. This is what is ordered by the usual direction "Full to MIXTURES." Now, we maintain that this method—perhaps the only one admissible under the old-fashioned system of organ-building—is a most undesirable and inartistic narrowing of the utility of all the compound stops. The same remarks apply to the octave, super-octave, and mutation stops. We should never think of applying the term *flexible* to a division of an Organ in which there are stops whose use is rigidly defined; and which cannot be drawn unless the full complement of stops is likewise drawn. When a Great Organ is made flexible, the general utility of all its stops is largely increased, and numerous charming tonal effects can be produced with perfect ease that are absolutely impossible on the same division as usually schemed.

When we speak of the Organ as being *expressive*, we mean that each and every one of its divisions is wholly or partly capable of *crescendo* and *diminuendo* effects, and, under certain conditions, of good *sforzando* effects also. Both flexibility and expression, in the sense we desire them to be understood, can alone be procured by the proper application of the swell in the Organ.

In applying the swell to the Great division, it is chiefly with the view, as has

already been said, of rendering it flexible. Such being the case, we advocate the inclosure in the swell-box of only such stops as call for special control and modification of tone. The double stop, whatever it may be, the DIAPASONS, probably all the unisons with the exception of the reeds, and the chief OCTAVE, should not be inclosed; but the other OCTAVES, SUPER-OCTAVES, all the mutation and compound stops, and the reed stops, should most certainly be inclosed in the swell-box. This box should immediately adjoin the exposed stops; and be constructed with the largest possible area of shutters or louvres. When fully open, there should be a refining effect on the tone only, without any practical loss of strength. It need hardly be pointed out how flexible such a Great Organ would be; for it must be seen at a glance that its complete harmonic structure, under the control of the swell, commanded by a balanced lever, would no longer be confined to full effects, but could be used in combination with the softest exposed unison stop in the division; or with any combination of stops in its own or any other division of the instrument.

In addition to the pleasing and effective tonal results obtained by means of the swell, striking and singularly rich effects can be produced by either a gradual or instantaneous entry of the full chorus into the full volume of unison and double tone yielded by the foundation-work. This is done by simply opening the shutters of the swell-box. Of course, the chorus has been heard all the time, but only as a mysterious background of refined harmonic tones so long as the swell-box remained closed.

In the ordinary expressive direction, the use of the swell in the Great division may be said to be very limited; indeed it may be accepted as practically confined to such stops as the reeds, when they are used for melodic or solo passages, or when they are employed to reinforce the DIAPASONS or non-expressive foundation-work. In the latter case, the effect is that of a *crescendo* on the TRUMPET, or whatever the chief reed may be, within a rich and steady volume of pure organ-tone. Such effects as we have shadowed forth are not to be heard in any Great Organ, or, in fact, in any single, uncoupled division in any of the Church or Concert Organs in Europe at the present time. We may conclude our brief remarks on the Great Organ, by giving the scheme of the division as prepared by us for the Organ in the Convention Hall, Kansas City, Mo.

GREAT ORGAN.

Compass CC to c^4=61 notes.

FIRST SUBDIVISION—UNEXPRESSIVE.

SUB-PRINCIPAL	Metal	32	FEET.	OPEN DIAPASON	Wood	8	FEET.
DOUBLE OPEN DIAPASON	"	16	"	GRAND FLUTE	"	8	"
CONTRA-GAMBA	"	16	"	DOPPELFLÖTE	"	8	"
SUB-QUINT	Wood	10⅔	"	GAMBA	Metal	8	"
GRAND PRINCIPAL	Metal	8	"	OCTAVE, Major	"	4	"
OPEN DIAPASON, Major	"	8	"	GAMBETTE	"	4	"
OPEN DIAPASON, Minor	"	8	"				

SECOND SUBDIVISION—EXPRESSIVE.

Inclosed in Swell-box No. 1.

Grobgedeckt	Wood	8 feet.	Grand Cornet IV. ranks.	Seventeenth	Metal	$1\frac{3}{5}$ feet.
Harmonic Flute	Metal	8 "		Nineteenth	"	$1\frac{1}{3}$ "
Quint	"	$5\frac{1}{3}$ "		Septième	"	$1\frac{1}{7}$ "
Octave, Minor	"	4 "		Twenty-second	"	1 "
Harmonic Flute	"	4 "	Grand Mixture			VII. ranks.
Tierce	"	$3\frac{1}{5}$ "	Double Trumpet		"	16 feet.
Octave Quint	"	$2\frac{2}{3}$ "	Harmonic Trumpet		"	8 "
Super-Octave	"	2 "	Harmonic Clarion		"	4 "

The Expressive Subdivision is brought on and thrown off the Great Organ clavier by thumb pistons: and it is also commanded by the Double Touch of the clavier, at the will of the performer.*

Many pages could be filled with a mere outline of the numerous beautiful tonal effects and colorings that this one Great Organ is capable of producing under the hands of a skilful organist—effects and colorings absolutely impossible on any Great Organ in existence, and, indeed, on any Organ, with all its united resources, ever constructed by a European builder. We ask the reader, if he is an accomplished organist, or a musician skilled in the art of organ registration, to carefully analyse the above Great Organ scheme, and work out for himself some of the practically countless problems and tonal combinations it presents; bearing in mind that, without any resort to expression, all the voices inclosed in the swell-box are capable of being fixed at any degree of strength of tone, within the limits of their full power and the *pianissimo* created by the closed swell, as previously described.

We now come to the next division of the Organ, commonly called the Choir. We here keep to the old-fashioned and familiar terminology, so as not to run the risk of confusing the reader: but we do not approve of that time-honored terminology, as we more fully state elsewhere, because, for instance, it seems little short of an absurdity to use the term Swell Organ for any one division of an Organ in which every division may be wholly or partly inclosed and rendered expressive. And it does not seem very appropriate or logical to speak of the Choir Organ, when the division to which that name is applied is not in any direct way related to an architectural or a vocal choir. More on this question need not be said here.

Whatever the tonal constitution of the Choir Organ may be, and whether it is schemed as an accompanimental, or simply a soft-toned, division of the Organ, there can be no valid objection raised to its being endowed with flexibility and powers of expression. The only question is: Should *all* its tonal forces be inclosed in a swell-box, or should they be divided as in the case of the Great Organ? We

*In the matter of the stop nomenclature of this immense Organ, our wishes were overruled by the conservative desire of the builders to adhere as closely as possible to old and familiar names. A much more satisfactory and consistent nomenclature could and should have been adopted in an instrument which departs, in other directions, so radically from the traditional methods of appointment.

are of opinion that, as the division is seldom a large one, it should be entirely expressive. The late Messrs. Roosevelt followed this practice, placing all the Choir stops in the same swell-box with the expressive subdivison of the Great Organ. There is no valid objection to this economical course; for there is little chance of the two divisions interfering with each other; or of being used independently, at the same time, in any manner calculated to cripple the expressive handling of the Choir stops. The arrangement would be favorable for coupling purposes. When used as an accompanimental division, it is obvious that the Choir Organ cannot be made too flexible and expressive. It has always offended our musical sense to hear a highly trained choir of voices, expected to sing with true and refined expression, accompanied on divisions of an Organ which are totally devoid of expressive powers. In this direction we may be hypercritical: but are we asking too much in desiring the instrumental accompaniment to be expressive and in strict keeping with the vocal music? It is quite certain, if the accompaniment was orchestral, the greatest degree of expression would be insisted on.

We have carefully considered the matter in all its bearings, and have come to the conclusion, that whatever use the so-called Choir Organ may be put to, that use is improved and increased tenfold by possessing powers of expression and being under absolute control as regards strength of tone. While it is not necessary to go into details at any length, there is one stop which is commonly placed in the Choir division in the works of the greatest English builder, and in those of his host of imitators, that we must direct attention to. This stop is the CLARINET; probably the most perfect imitation of an orchestral instrument the organ builder has produced. Now, in nine cases out of ten, this important and characteristic stop is found in the Choir of modern Organs, and, accordingly, entirely devoid of light and shade or powers of expression, and in no way under tonal control. Such an inartistic, unmusical, and thoughtless blunder as this, is a disgrace to modern organ-building; and how it has so long been tolerated by organists, not to say calmly specified by them, is a mystery we cannot fathom. If there is one stop in the Organ which more than another calls with imperative voice for flexibility and full expression, it is the CLARINET. It would be just as unseemly and absurd to insist that the Clarinets of the orchestra be played at all times at their full strength of tone and without a trace of expression, as it is unseemly and absurd to insert the CLARINET stop in an unexpressive division of the Organ. Allowing that the Choir stops are inclosed in the swell-box that contains the expressive subdivision of the Great Organ, it follows that one balanced expression-lever only is required for controlling both divisions.

So far as the application of the swell-box is concerned, it is hardly necessary to make a special plea for the division commonly known as the Swell Organ: but whatever its tonal constitution may be, it is, of course, essential that its swell-box be independent from the other swell-boxes in the instrument, and controlled by a special balanced expression-lever.

On the suggestion made elsewhere, in connection with the Concert-room Organ, as to the advisability of dividing the tonal forces of this very important

division into two subdivisions, and of inclosing each in a separate swell-box, nothing need be said in this place. Such an arrangement will, in all probability, be adopted only in Concert-room Organs and instruments designed on similar lines. We believe we were the first to devise and advocate this radical departure from old methods. Even in the ambitious scheme prepared by Mr. Roosevelt for the Sydney Organ no such tonal division appears. This is not to be wondered at, seeing that he overlooked the still more important addition which we shall advocate shortly. Our scheme of dividing the so-called Swell Organ, and inclosing the two subdivisions in separate swell-boxes, is carried out in its full development in the Organ in the Convention Hall, Kansas City. The first subdivision comprises twenty-three complete stops, including all the stops representing the "wood-wind" of the orchestra, all of which are inclosed in swell-box No. 2. The second subdivision comprises fourteen complete stops and eighteen ranks of pipes representing the full string forces of the orchestra, all of which are inclosed in swell-box No. 3. This remarkable string-toned subdivision is brought on and thrown off the Swell Organ clavier by thumb pistons: and it is also commanded by the Double Touch of the clavier.

We now come to the Solo Organ; and here we are in the presence of another important division of the modern Organ respecting which difference of opinion obtains in matters of flexibility and expression. And when one glances at the largest and finest Organs built by the greatest English builder, and finds their Solo divisions fixed and unexpressive, one may be pardoned in halting before insisting on the absolute necessity, from a musical point of view, of the application of the swell to the Solo Organ. "Great men have great failings;" and we venture to think that the neglect of the Solo Organ, in this matter of flexibility and expression, is a very great failing, in an artistic sense, in the builder of these large Concert Organs, and one that is as unexcusable as it is extraordinary.

The very name given to the division is surely enough to indicate that it should, even above and before every other division of the Organ, be furnished with the highest powers of flexibility and expression that skill and ingenuity can devise.

Imagine, ye Musicians, a *solo* of any description without light and shade, innocent of a *crescendo* or *diminuendo*, full of unyielding *forte*, and guiltless of a single *piano*. Can you reconcile such a thing to your musical sense? The organist, satisfied with matters as they are, with ears vitiated by the crudities of modern organ-building, may say: "I do not expect the refinements of an orchestral solo from the Solo Organ. What I want is plenty of free sound. Just imagine," he adds, "my beautiful TUBAS endowed with light and shade—heaven forbid that they should have their glorious stentorian voices afflicted with powers of expression. Powers of expression forsooth! I want them, and all such stops, to enter into *my* music like bellowing bulls and as roaring lions; not like the approach of distant thunder or as the swelling voice of mighty Boreas; and I want them to *roar* at *all times* and in *all kinds of music* at their *full blast*." On the other hand, the organ builder may say: "Inclose my solo reeds?—Reeds that I have voiced on wind of sufficient power to blow a blast-furnace, and which are sufficient to

split your ears—Never! Expressive powers?—Humbug! If you cannot play the Organ as I choose to build it, you had better give it up and go into the vocal or orchestral line, where you can revel in expression to your heart's content."

Well, we shall willingly leave both the illogical and inartistic organist and organ builder to nurse their own opinions; and take our stand in favor of the highest powers of expression that can be given to the Solo Organ. It is usual, and we may say correct, to place in the Solo division stops imitative of the more assertive instruments of the orchestra, and those powerful labial and reed stops whose voices pierce through the entire volume of the Organ: but is it scientific or even sensible to leave such assertive and dominating voices absolutely without any means of modification and incapable of expression? Surely not. Cannot we learn the true lesson from the orchestra here if our own musical knowledge and common sense is insufficient to guide us?

It has been asserted, by lovers of noise, that to inclose such stops as the high pressure reeds is to destroy all their attack and grandeur. We unhesitatingly reply that their entry or attack requires a good deal of destroying; whilst anything that can tone down their so-called *grandeur—blatant blast* would, in many cases, be a more appropriate term—should be hailed as a blessing. But the truth is, inclosure in a properly constructed swell-box, would only very partially meet these desirable ends. When the box is closed, of course the tones of the TUBAS are softened to an extent which renders them agreeable; but when it is fully opened, they are practically heard at their full power: all that the swell-box can do is to slightly soften the unpleasant roughness of the vibrating tongues of the reeds, and this is decidedly a gain.

It is acknowledged by every educated organist that the heavily-blown reed stops, as inserted in modern Organs, can only be very sparingly used, and, in playing, have to be *led up to.* Now, admitting the value of such imposing voices, we consider this an objectionable and regrettable narrowing of their utility. If the stops now placed, in an exposed condition, in the Solo division of modern Organs, were inclosed in properly constructed swell-boxes, their value would be immensely increased; and the effect of their entry, by means of a *crescendo*, or quasi *sforzando*, would be impressive in the extreme, without being irritatingly startling, as it almost invariably is, to the sensitive musical ear under the existing crude system.

One of the alterations made in the Grand Organ in St. George's Hall, Liverpool, during its recent reconstruction, is the inclosing of portion of the Solo division in a swell-box: but strange to relate, the four heavily-blown reeds—the OPHICLEIDE, TRUMPET, CLARION No. 1, and CLARION No. 2—are left exposed. We are certainly at a loss to understand such a proceeding; for it was the continued observation of the behavior of these identical stops, during the many years of our experience of the late Mr. Best's playing, that impressed us with the necessity of imparting full powers of flexibility and expression to the Solo Organ.

When any of the Solo Organ stops are used for solo or melodic passages, the necessity for powers of expression becomes unquestionable. Among the stops which, in our opinion, should find a place in the Solo division of a Concert Organ

are the following: Concert Violin, Concert Violoncello, Concert Flute, Orchestral Trumpet, Cornopean, Orchestral Clarinet, Trombone, Ophicleide, Bass Tuba, Tuba Mirabilis, Harmonic Tromba, and Harmonic Clarion. Can any musician, with a spark of refinement in his soul, offer a single logical or artistical reason why such stops as these should be left in the Organ in a state beyond all control, and without powers of expression? If he can; just as a matter of curiosity, we should like to hear it.

To those who accept the opinion that all the manual divisions of the Organ should be wholly or partly expressive, the proposition that the Pedal Organ should also have powers of expression and flexibility given to it will not only seem reasonable but perfectly logical. On the other hand, those (and their name is legion) who are satisfied with the old-fashioned style of organ-building, will condemn the idea of having an expressive Pedal Organ as an absurdity, in no sense to be encouraged. The opinions of organists on this question will, of course, depend largely, if not entirely, on the way they look upon and use the Pedal Organ.

To throw a little common sense into this matter we shall address a few words to the organist who is doubtful, and who has not made up his mind respecting the desirability of extending the application of the swell to the Pedal Organ.

We shall take it for granted that you are willing to admit that it seems desirable to have powers of expression given to the manual divisions of the Organ, and that you accept the idea, previously expressed, that the Organ shines with light borrowed from the orchestra. Now, let us glance at the orchestra and see if it can teach us anything in this Pedal Organ question. You naturally hold, after many years of experience as an organist, that there is no necessity for the Pedal Organ to be expressive or flexible; but at the same time you desire to be consistent and logical in all musical matters. Let us take a few instruments of the string family,—say a string quartet, which you know consists of first Violin, second Violin, Viola, and Violoncello or Bass,—and see if we can learn anything to guide our uncertain steps. You will admit that during the performance of a Quartet, the parts for the two Violins and the Viola must be rendered with all the expression and *nuances* the music demands: but, bearing the unexpressive Pedal Organ in view, you will very naturally say that the composer never intended the bass part to have any expression; and that before starting a Quartet by Beethoven or any other composer, the violoncellist should receive strict injunctions to play his part all through at the full strength of his bow, and without the slightest *diminuendo* or expression of any sort. You will tell him to take the bass division of the "King of Instruments" for his model, and go on, in the even tenor of his way, regardless of what the other instrumentalists are doing.

Now, take the full orchestra—"the Sun in the musical universe"—and see what can be done with it. The Conductor, before commencing a Symphony, will, of course, address his forces thus: "All the Violins, Violas, Flutes, Oboes, Clarinets, and all the treble and tenor instruments generally, are to render their respective parts with the greatest refinement, delicacy, and expression, paying strict attention to the *piano* and *pianissimo* passages. But, on the other hand, all the Violoncelloes, Double Basses, Bassoons, Bass Trombone, and all the bass instruments

generally, are to render their respective parts uniformly, throughout the Symphony, at their full power, and without the ghost of a *diminuendo*, even when all the rest of the orchestra is playing *pianissimo*."

We need not ask the musician what his opinion of such a performance would be, or what he would think of the Conductor who proposed such an outrageous proceeding: but we can assure him that we look upon a performance on an Organ in which all the powers of expression are confined to the manual department as equally objectionable and inartistic.

If Dr. Hans von Bülow felt tempted, for a moment, to jeopardise his "pianistical career" and to "study the Organ," on hearing Mr. Best's performance on the Glasgow Organ, with its very limited powers of expression; and that mainly on account of its "flexibility and expression," its "most delicate and exquisite *nuances*," and its "*diminuendi* and *crescendi;*" what would he have said had he heard the same performer on an Organ such as we advocate, endowed with powers of expression and made perfectly flexible throughout its entire tonal forces and in every division? Such an Organ would indeed be an instrument for the *virtuoso*—on which he could interpret his deepest and most refined musical thoughts; and on which he could produce the richest effects of light and shade, vivid contrasts, and all those "delicate and exquisite *nuances*," which are now only heard in the orchestra. But to make the Organ an instrument for the *virtuoso* and profound musician, we are free to admit that more must be done than merely giving it powers of expression and complete flexibility by means of the swell. Its entire tonal forces must be classified and arranged upon a far more artistic and scientific system than that which obtains at the present time. For further remarks on this important subject, the reader is referred to the Chapter on the Concert-room Organ.

It is well known that the bass sounds of the Organ have much the most effect on the ear; and that they are heard distinctly at a much greater distance than either the tenor or treble sounds. These facts alone should be sufficient to convince the musician that flexibility and expression are absolutely essential to the great bass department of the Organ.

It is but proper to state that a few efforts have been made by organ builders in this direction. The earliest example known to us is furnished by the Organ built by Walcker and Co., of Ludwigsburg, for the Music Hall, at Boston, Mass., in the year 1862. In this important instrument six of the Pedal Organ stops were inclosed in the Swell Organ box. These were the BOURDON, 16 FT., BASSOON, 16 FT., FLUTE, 8 FT., VIOLA, 8 FT., FLUTE, 4 FT., and WALDFLÖTE, 2 FT. In the same builders' Organ, erected in 1883, in the Cathedral of Riga, we find eight Pedal Organ stops inclosed in a swell-box along with the stops of the Fourth Manual. The Pedal stops are the VIOLONE, 16 FT., BOURDON, 16 FT., SERPENT, 16 FT., VIOLON, 8 FT., DULZFLÖTE, 8 FT., BASSETHORN, 8 FT., VIOLA, 4 FT., and FLAUTINO, 2 FT. Seeing that the Swell was neither invented in Germany nor its use encouraged there for a long period, it is somewhat remarkable that the first important step toward making the Pedal Organ expressive should have been taken by the leading German organ builders.

In England, the only complete example of an expressive Pedal Organ is met with in the Organ of the Carmelite Church, Kensington, London, in which we find all the pedal stops inclosed in the general chamber which contains the Great Organ. This interesting instrument has also an independent Swell Organ. It was, as already mentioned, constructed by A. Cavaillé-Coll, of Paris. Although in two or three instances attempts have been made to improve the character of the Pedal Organ, by inclosing some of its stops in the Swell Organ box, practically nothing of importance has been accomplished by English builders in this direction.

In conclusion, we may say that we strongly advocate a much more systematic treatment than any furnished by the above examples, or by any that can be pointed to in existing Organs. In our opinion, a considerable portion of the Pedal Organ should be inclosed in a large and specially constructed swell-chamber, and so made independently flexible and expressive. For the convenience of the performer, and to enable him to control the pedal forces with ease, a mechanical arrangement should be provided, by means of which he can, at will, connect the pedal swell shutters to any one of the balanced expression-levers belonging to the manual divisions. With a properly-appointed and expressive Pedal Organ, the performer can readily obtain a suitable bass for all his expressive manual divisions: and his perfect control over the strength of tone of the pedal forces, allows him to graduate his bass at all times to suit his manual tones. The swell when properly applied, increases the beauty and utility of the Pedal Organ tenfold. We commend what we have said in the present Chapter to the unbiased consideration of organists and musicians generally. They alone can compel the organ builder to depart from his conservative and old-fashioned views and ways of doing things.

CHAPTER XIX.

THE MANUAL CLAVIERS.

THE several successive stages of development through which the Manual Claviers of the Organ have passed form a very interesting chapter in the History of the King of Instruments; so much so, that, although we have touched upon the subject in our historical notes, we may appropriately enlarge upon it as an introduction to the present Chapter. We may pass over the primitive form of clavier, which appears to have consisted of a series of projecting rods, levers, or handles, which were moved in some direction so as to operate the sliders or valves which admitted the compressed air to the pipes, and commence our brief survey at the point where we find some reliable information.

This point may, perhaps, be safely taken at about the middle of the fourteenth century, when the large Organ at Halberstadt was constructed by an ecclesiastic named Nicolaus Faber; although certain authorities have placed the point so far back as the eleventh century, during which an Organ, having sixteen manual keys, is stated to have been built for the Cathedral of Magdeburg. At this early period the Organ was in a primitive state; and our knowledge of its form, compass, and construction is extremely slight and altogether unsatisfactory. What this early Magdeburg Organ was like no one knows. Prætorius, in his "Theatrum Instrumentorum seu Sciagraphia," gives an engraving of two large keys, apparently represented full size, which is inscribed "Gross Magdeburgisch Clavier." From whatever source Prætorius may have obtained the form and dimensions of these remarkable keys, they cannot reasonably be accepted as those of the keys of the Organ constructed in the eleventh century. In the accompanying illustration, Fig. LXXIV., is given an outline reproduction of this engraving, full size. It will be observed that no chromatic key is shown, and this omission would seem to indicate a clavier of an early date, but not necessarily one of so remote a period as

the eleventh century. In the "History of the Organ," which forms the first part of the work entitled "The Organ, its History and Construction," a drawing is

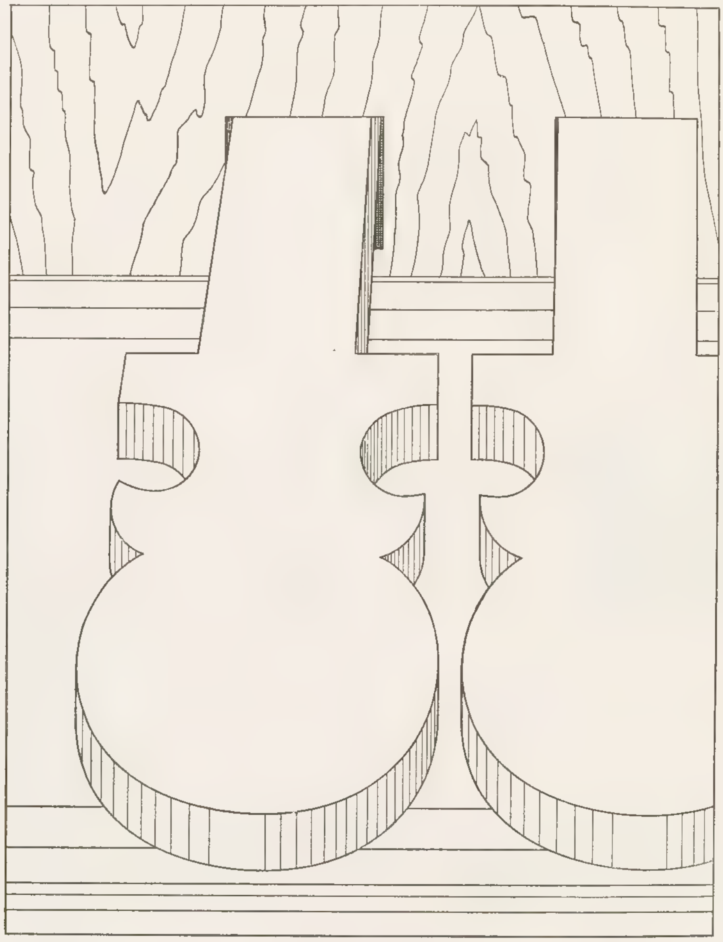


FIG. LXXIV.

given, as copied from the engraving in the "Theatrum Instrumentorum seu Sciagraphia," and described as representing the clavier of the great Magdeburg Organ.*

* "The Organ, its History and Construction . . . . Handbook for the Organist and the Amateur," by E. J. Hopkins and E. F. Rimbault, LL. D., London, 1870 : page 32.

This is a strange mistake for the learned author to have made; for the engraving given by Prætorius, from which that in Dr. Rimbault's essay has been copied, represents the "discant clavier" of the great Organ of Halberstadt. It is to be regretted that a mistake of this kind should have been made in a treatise of so much importance, especially as the work by Prætorius is not easily accessible to the ordinary reader. The mistake is apt to confuse the ideas of the student. We give farther on a correct outline drawing of the Halberstadt keys, of the form and size shown in the "Theatrum Instrumentorum seu Sciagraphia." The keys of the early Magdeburg Organ are stated, on what authority we know not, to have been an ell in length by three inches in width. Now, as the ell of that period was about two feet of our measurement, the entire length of the key body or stock, and not merely its playing or exposed portion, must surely be alluded to. In the apparently full size representation of the keys, given by Prætorius, the extreme width is slightly over two and a half inches; amply wide enough to be struck down by the fist, as the early keys are reported to have invariably been manipulated.

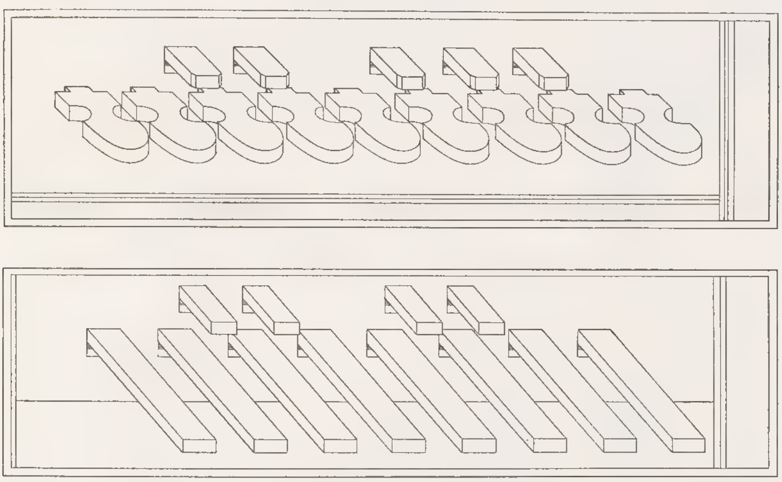


Fig. LXXV.

In Plate XXV. of the above-mentioned treatise, Prætorius gives two interesting engravings of the manual claviers of the great Organ at Halberstadt, constructed by Nicolaus Faber in the year 1361, and renovated by Gregorius Kleng in 1495. Accurate outline copies of these engravings are given in Fig. LXXV. Both these claviers are so represented as to convey the idea that they are complete. The upper "discant clavier" has fourteen notes, marked thus: ♮, C, C♯, D, D♯, E, F, F♯, G, G♯, A, ♭, H, C; while the lower clavier has twelve notes, marked thus: ♮, C, C♯, D, D♯, E, F, F♯, G, G♯, A, H. It will be observed that

the larger keys of the upper clavier somewhat resemble those of the "Gross Magdeburgisch Clavier" as depicted by Prætorius, being likewise intended to be beaten by the closed fists of the performer; while the chromatic keys are straight pieces

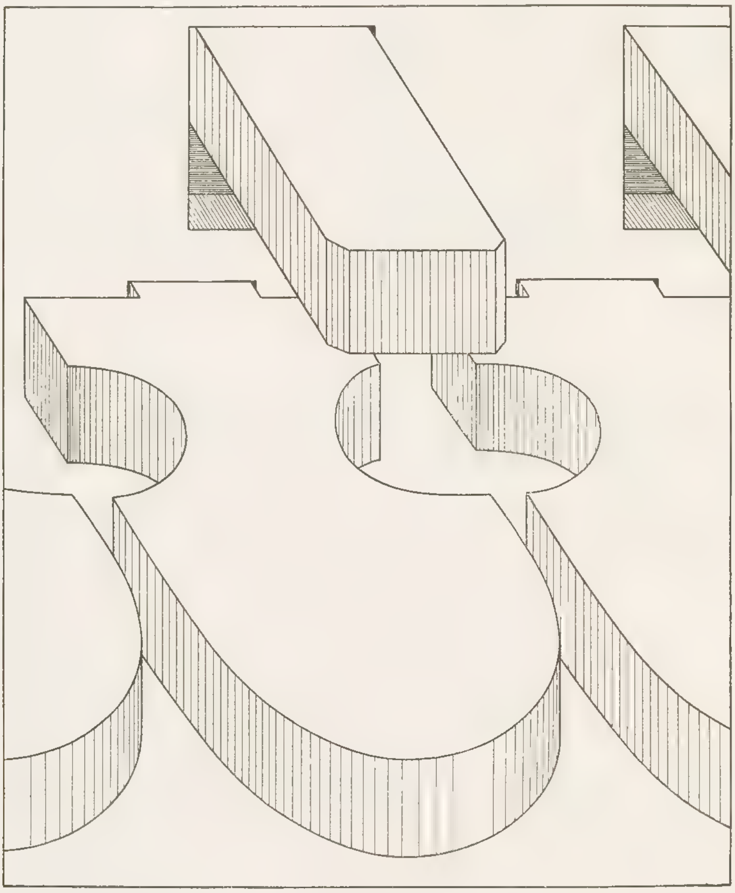


Fig. LXXVI.

of wood sufficiently large to be depressed in a similar fashion. Prætorius, who seems to have been conversant with the details of the Halberstadt Organ, gives a full size representation of the keys just alluded to. Of this engraving we give a correct outline copy in Fig. LXXVI. Although measurements taken from a per-

spective drawing cannot be depended upon, there can be little doubt that the natural keys of this clavier were about three inches in width. The length of their playing portions can only be guessed at from the engraving given. The lower

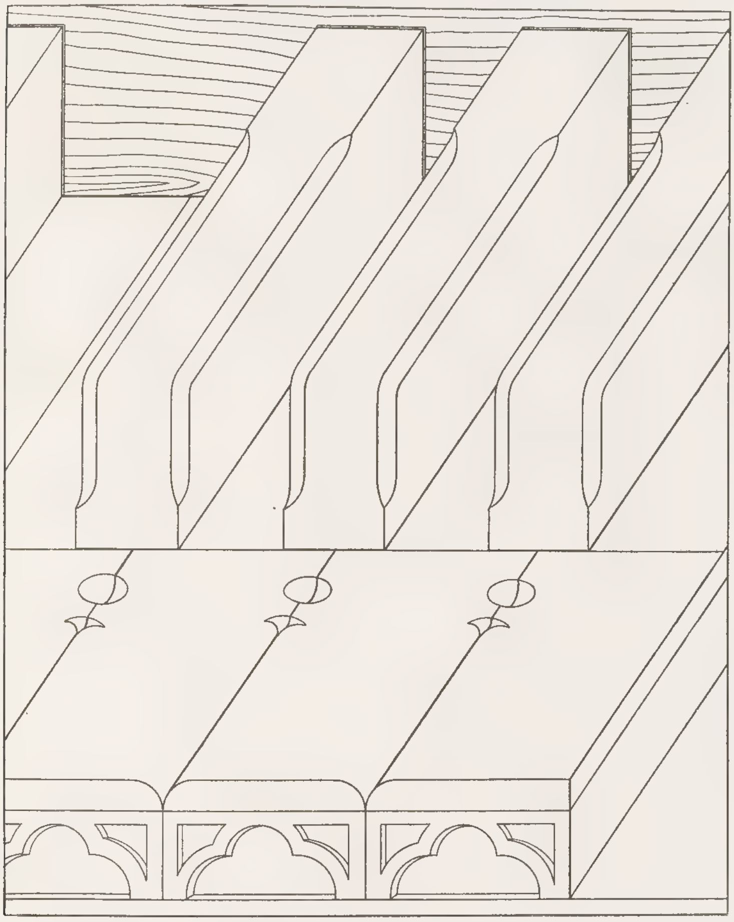


Fig. LXXVII.

clavier, shown in Fig. LXXV., differs widely, in the form of its larger keys, from the upper clavier. Here the keys are straight quadrangular rods or levers of wood, no doubt intended to be depressed by some forcible application of the hands.

Accepting the claviers of the Halberstadt Organ, as depicted by Prætorius, to

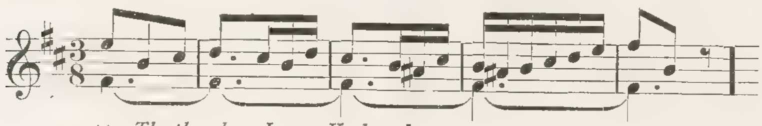
have belonged to the original instrument constructed in the year 1361, we find considerable progress to have been made in the form and proportions of the manual clavier during the succeeding ninety-five years. In the year 1456, an Organ was erected in the Church of St. Egidius, at Brunswick, having manual claviers which, clumsy though they were, marked a decided step toward the modern treatment. Prætorius gives full size representations of portions of two manual claviers belonging to this instrument, showing keys of different dimensions.* The engraving showing the smaller keys is reproduced, in outline, in the illustration on the preceding page, Fig. LXXVII. This engraving is inscribed: "Clavier zum Rückpositieff in derselben [alten] Orgel—S. Egidii zu Braunschweig." The keys, while they were similar in disposition to those of the modern clavier, were large and clumsy, so much so that an ordinary hand could not comfortably stretch beyond the interval of a major sixth. From this date the manual keys were gradually reduced in size, as the compass of the clavier was increased, and the mechanism of the Organ was improved and lightened, until we find that in the Organ built by Cranz, in the year 1499, for the Church of St. Blaise, at Brunswick, the keys were sufficiently reduced in width to admit of the octave being easily spanned by the hand. The sixteenth century saw the correct or approved scale of the manual keys established, practically in the form now adopted. The above brief historical notes form a suitable and instructive introduction to the practical matters discussed in the present Chapter.

The manual claviers, or keyboards for the hands, are very important portions of the mechanism of the Organ; for on their proper form and disposition depend, to a large extent, the comfort of the performer and his easy control over the tonal forces of the instrument. That they do not always receive the consideration they deserve on the part of the organ builder is very obvious to any one who critically examines numerous Organs constructed by different builders both here and abroad. Certain types of clavier arrangement are preferred by individual builders; and these are often adhered to, regardless of the imperfections or shortcomings they obviously present, and without any protest from the organ-playing world. It is to be regretted, we venture to think, that a uniform treatment and standard measurements in the associated claviers have not been arrived at by organ builders, and approved of by the leading organists of the world; for such a uniformity could not fail to be convenient and acceptable to both players and builders. It must be remarked, however, that groups of two, three, four, and five claviers would each call for a special uniform treatment; because it is obvious that, in the matter of relative position alone, a treatment perfectly well adapted for two claviers would not be equally suitable for the groups of three, four, or five claviers: still general principles should obtain, in this matter of relative position, in the arrangement of all the groups. For instance, it is desirable that the claviers should be brought as close together as possible, without interfering with the proper length of the black keys, or with the free movement of the fingers of the performer thereon. It should be rendered possible for such a passage as is here given—from a composition for

* "Theatrum Instrumentorum seu Sciagraphia," Plates XXVII. and XXVIII.

the Organ—to be readily played by the right hand alone on any two adjacent claviers:

Right Hand alone. *Fingers on Upper Keyboard.*



×—*The thumb on Lower Keyboard.*

This is the test of position advocated by the celebrated organist, the late Mr. W. T. Best, of Liverpool.

Before we enter on the description of the varied forms and treatments of the four groups of claviers, as introduced by different organ builders, we may profitably touch upon the dispositions of the claviers, commanding the several manual divisions of the Organ, as met with in executed works. In the following remarks it will be understood that the claviers are numbered from the lowest one upward: the lowest being invariably the First Clavier, while those placed above it are, respectively, the Second, Third, Fourth, and Fifth Claviers. Each of these claviers commands the tonal forces of a different division of the Organ; and to which a distinctive name is given, more or less expressive of its office or tonal character.

In the groups of two manuals, practically no diversity of practice obtains; the First Clavier invariably commanding what is called the Great Organ, and the Second Clavier commanding what is usually a subordinate division, called either the Swell Organ or the Choir Organ; the latter term being used when the division is of a softer tone than the Great Organ, and not necessarily expressive.

In the groups of three claviers three dispositions are met with. First:—the First Clavier commanding the Great Organ, the Second Clavier the Choir Organ, and the Third Clavier the Swell Organ: many examples of this disposition are to be found in instruments both here and abroad. We find it in Merklin's Organ in the Cathedral of Senlis (Oise), and in Walcker's Organ in the Protestant Church, at Mülhausen. Second disposition:—the First Clavier commanding the Great Organ, the Second Clavier the Swell Organ, and the Third Clavier the Choir Organ. This disposition is uncommon and is by no means to be recommended. In the case of a Chamber Organ, the manual divisions of which are a Great, a Swell, and a Solo, the Swell may be commanded by the Second Clavier and the Solo Organ by the Third Clavier; indeed, this is the correct disposition. In the interesting Organ erected by Schulze in the Petrikirche, at Soest, in Westphalia, we find a powerful Great Organ commanded by the First Clavier, and an extremely delicate Choir Organ, voiced on very light wind, commanded by the Third Clavier. The Second Clavier commands a division of the instrument which in general intensity of tone is intermediate with respect to the tones of the other two divisions. This second division should most certainly have been rendered expressive; and would have been made a Swell Organ had the instrument been

constructed by an English, American, or French organ builder. According to the ideas which obtained in Germany at the time this Organ was constructed, both its tonal appointment and clavier disposition left nothing to be desired. Third disposition:—the First Clavier commanding the Choir Organ, the Second Clavier the Great Organ, and the Third Clavier the Swell Organ. While this disposition frequently appears in the groups of four claviers, it is not to be recommended for the triple claviers. We do not believe that this disposition was ever adopted for the convenience of the performer; but that it grew out of the old position of the Choir division of the Organ, and the natural desire to obtain a simple and convenient tracker action between it and its clavier. Certain distinguished modern organists, including the late Mr. W. T. Best, have advocated the abandonment of this old disposition in favor of the first disposition, given above, in which the clavier commanding the Choir Organ is placed between those of the Great and Swell Organs. This arrangement has been claimed to be convenient, because it places the most useful accompanimental clavier immediately under the clavier commanding the division most suitable for expressive solo effects and expressive passages generally. The old disposition, of Choir, Great, and Swell, has found many advocates among modern organists; but upon what grounds, save that of long usage and familiarity, we have failed to discover. Organ builders, naturally, are prejudiced in favor of old methods of doing things, so they have not moved actively in this matter of arrangement. They will carry out any disposition of the claviers required by their clients.

In the groups of four claviers, five different dispositions may be mentioned as obtaining in certain representative Organs. First:—the most desirable disposition, in which the First Clavier commands the Great division, the Second Clavier the Choir division, the Third Clavier the Swell division, and the Fourth Clavier the Solo division. We find this disposition in Cavaillé-Coll's Organ in Albert Hall, at Sheffield, in which the Positif, Récit, and Solo are all expressive, and are commanded respectively by the Second, Third, and Fourth Claviers. The Grand-Orgue is commanded by the First (lowest) Clavier. This instrument was built under very careful direction, and the disposition of its claviers received proper consideration. The large Organ reconstructed by Merklin in the Church of Saint-Eustache, Paris, presents a disposition differing only very slightly from the preceding, the Fourth Clavier commanding the division peculiar to French instruments, designated the Bombarde. This name is given to the division which contains the powerful reed stop, of 16 ft. pitch, called the BOMBARDE. We strongly recommend the adoption of this first disposition for all Organs having four manual claviers. We were assured by the late Mr. W. T. Best that, after his long experience in connection with Organs of all kinds, he considered this disposition the most logical and convenient one. It is certain that no one who has lived in the nineteenth century had a better right to be dogmatic on such a subject than this consummate master of organ technique. It is true, however, that in his scheme for a certain important Concert-room Organ he departed decidedly from this disposition, as will be seen farther on. A modification of this first disposition is met with, in which the divisions commanded by the Second and Third Claviers change places: in this

case the First Clavier commands the Great, the Second Clavier the Swell, the Third Clavier the Choir, and the Fourth Clavier the Solo Organ. Second disposition :—that illustrated by the large Organ constructed by Willis in St.George's Hall, Liverpool. In this instrument the First Clavier commands the Choir Organ, the Second Clavier the Great, the Third Clavier the Swell, and the Fourth Clavier the Solo Organ. This disposition is also met with in Roosevelt's important instrument in the Auditorium at Chicago. The practice of connecting the Choir Organ to the First (lowest) Clavier in all probability originated, as has already been mentioned, when that manual division was placed, in an independent case, in advance of the main portion of the Organ and behind the organist as he sat at the keys. This arrangement is clearly shown by Dom Bedos in one of his plates.* Here the performer is seated between the main body of the instrument and the advanced Positif. The action is carried direct from the First Clavier by vertical stickers to long backfalls which extend underneath the pedal keys to the pallet-box of the Positif wind-chest. No action could be simpler or more direct than this. There is at the present time no necessity of continuing the undesirable position of the Choir Organ clavier. Third disposition :—that illustrated by the Organ in the Town Hall of Bolton, Lancashire. In this instrument, which was constructed from the specification and under the direction of the late Mr. W. T. Best, we find the First Clavier commands the Choir Organ, the Second Clavier commands the Great, the Third the Solo, and the Fourth the Swell Organ. This disposition, so far as the Third and Fourth Claviers are concerned, is unique so far as our knowledge goes. The location of the Solo clavier, between the Great and Swell claviers, was doubtless suggested by Mr. Best's special taste and style in the rendition of orchestral scores on the Organ, which so frequently called for the operation of the fingers of one hand on two adjacent key-boards at the same time. In the disposition of the claviers of Concert-room Organs, on which complex orchestral compositions are certain to be played, such a matter as the above should receive careful consideration, in combination with the tonal appointment of the several divisions affected. It must be mentioned that the Solo division of the Bolton Organ is rendered expressive by being inclosed in a special swell-box. In the Organ in the Church of Saint-Nicolas, Fribourg, we find a disposition closely resembling the one above described; the only difference being in the Third Clavier, which commands the division called the Bombarde, although it contains no BOMBARDE, 16 FT. Fourth disposition :—illustrated by the Grand Organ in the Church of Saint-Ouen, at Rouen. In this notable instrument, constructed by Cavaillé-Coll, the First Clavier commands the Grand-Orgue, the Second Clavier the Bombarde, the Third Clavier the Positif, and the Fourth Clavier the Récit expressif. For Organs of four manual claviers, appointed according to the usual modern French method, this disposition has several advantages. In the Organ in Saint-Ouen the Récit expressif is a combination of a Swell and a Solo Organ, while the Positif is well adapted for accompaniment; accordingly, these divisions are very frequently used together. The stop appointment of the Grand-Orgue

* "L'Art du Facteur d'Orgues:" Plate LII.

and the Bombarde, makes the latter practically a part of the former, hence their claviers are properly placed adjacent to each other. As a general rule, divisions that are closely allied, and more or less dependent on each other for important tonal effects, should have their claviers adjoining. This rule has been commonly observed by French organ builders in their larger instruments. Fifth disposition: —illustrated by the large Concert-room Organ in the Town Hall of Leeds, Yorkshire. In this instrument, the First Clavier commands the Choir Organ, the Second Clavier the Swell, the Third Clavier the divided Great, and the Fourth Clavier the Solo Organ. There is also an Echo Organ commanded by both the First and Fourth Claviers. The position of the Great Organ clavier is, so far as we are aware, unique; and it is certainly difficult to account for so radical a departure from the commonly approved and more correct positions. Certain other dispositions may be found in some German Organs, but of these it is unnecessary to speak.

In the groups of five claviers, three dispositions may be given as presented by notable Organs. First disposition:—represented by the large Concert-room Organ in the Centennial Hall, at Sydney, N. S. W., constructed by Hill & Son. The First Clavier commands the Choir Organ, the Second Clavier the Great, the Third Clavier the Swell, the Fourth Clavier the Solo, and the Fifth Clavier the Echo Organ. This is the second disposition given in the groups of four claviers, with the simple addition of the Fifth or Echo Clavier. The disposition is doubtless a satisfactory one; the only question open to consideration is that commented on in our remarks on the disposition introduced by Mr. Best in the Organ in the Town Hall, Bolton. Second disposition:—that introduced by Cavaillé-Coll in the Grand Organs in Notre-Dame and the Church of Saint-Sulpice, at Paris. The First Clavier commands the Grand-Chœur, the Second Clavier the Grand-Orgue, the Third Clavier the Bombarde, the Fourth Clavier the Positif, and the Fifth Clavier the Récit expressif. In considering this disposition it should be borne in mind that the Grand-Chœur is practically a dependent division, containing the stops, designated by the French builders *jeux de combinaison*, which complete the tonal appointment of the Grand-Orgue. The Grand-Chœur must not be confounded with the Choir Organ, commanded by the First Clavier, in many English and American instruments. As will shortly be seen, the divisions called the Grand-Orgue and the Grand-Chœur may be properly commanded by one clavier, showing their close connection in the tonal scheme. Taking the stop appointments of the remaining divisions of these Organs into consideration, and bearing in view the fact that each instrument has only a single expressive division, it seems questionable if the Récit expressif is commanded by the most convenient clavier. In our opinion no division of an Organ is of more importance than its expressive one; and, accordingly, it should be commanded by a clavier within easy reach of the organist's hands. The highest and farthest away of five claviers cannot be considered a very convenient one for a lengthened use by both hands, while it is well adapted for occasional passages, more or less of a solo character, rendered by a single hand. Important, according to French ideas, as the Bombarde may be in the production of full effects, it is certainly of secondary

importance to the Récit expressif in both the Organs under consideration; and, accordingly, might have been transferred to the Fifth Clavier, allowing the Récit to be commanded by the more accessible Third Clavier. Third disposition:—set forth in Cavaillé-Coll's grand project for the Organ for St. Peter's, at Rome. First Clavier commanding the Grand-Orgue and the Grand-Chœur,* the Second Clavier the Bombarde, the Third Clavier the Positif, the Fourth Clavier the Récit expressif, and the Fifth Clavier the Solo expressif. The relationship between the Grand-Chœur and the Grand-Orgue, already alluded to, is here clearly shown by placing them under the control of a single clavier. While this disposition is quite satisfactory from a French point of view, we are of opinion that it would be improved by transposing the positions of the Clavier de Bombarde and the Clavier du Récit expressif.

There is another branch of the present subject of unquestionable interest and importance to organists; namely, that relating to the position of the claviers with respect to the main body of the Organ. This position varies to quite a marked extent in the representative works of leading organ builders; and we shall, accordingly, refer to these works as examples during the following brief remarks.

The oldest and, at the same time, the most objectionable position of the claviers is that to be seen in far too many important instruments, and notably in the two largest Concert-room Organs in England, those in St. George's Hall, Liverpool, and the Royal Albert Hall, London. In these large instruments the claviers are recessed within the exterior lines of their case-work, and, accordingly, the organist occupies the most unfavorable position possible to judge of the tonal effects he is producing. Times out of number the late Mr. W. T. Best, who for about forty years presided at the former Organ, complained bitterly to us of the manner in which he was handicapped by the most objectionable position he was compelled to occupy while performing. In this almost buried position, the organist is likely to hear enough of the noise of the internal mechanism, especially if the pneumatic lever is introduced, to distract his attention from the more delicate musical effects he may be producing. We have observed this objectionable noise of the mechanism while at the keys of the Organ at Lucerne and other large Continental instruments which have recessed claviers. This direct position appears to have been favored by organ builders, most probably because it admits of the simplest and cheapest class of key action, draw-stop action, etc.: but we unhesitatingly say that it should never be adopted for Concert-room Organs, or, indeed, for important Organs of any class, when it can possibly be avoided. It is strange that no better position could be found for the claviers of the immense Concert-room instrument constructed in England only a few years ago—that in the Centennial Hall, at Sydney, N. S. W.

The second position, which also admits of a direct action, is, while far from perfect, much to be preferred to the "hole-in-the-case" one above alluded to. This second position is to be seen in the Concert-room Organs in the Town Hall of Leeds, and the Public Halls, at Glasgow, and also in several other instruments in

* M. Cavaillé-Coll remarks: "Cette 2e partie du premier clavier *Grand-Chœur* serait disposée pour être jouée séparément avec le *Grand-Orgue* sur le premier clavier."

a less pronounced form. Here the claviers are advanced somewhat in front of the main body of the Organ, but are still connected with the same. The action being carried direct from them into the Organ, the performer has to sit with his back to the orchestra and audience. In this case the organist is not so overshaded as in the first position of the claviers, and can form a much better idea of the tonal effects he is producing. When this advanced position is convenient, the claviers should be carried as far as possible from the front of the Organ; the farther they are the better it will be for the performer. In small Church and Chamber Organs a very simple treatment of the advanced claviers commonly obtains; the claviers being only brought sufficiently far from the front of the case to admit the pedal clavier to assume its proper relative position, without requiring to be recessed within the general case line. This position of the claviers is generally satisfactory for small instruments, and is quite suitable for all classes of action: but when it is adopted for so large a Concert-room Organ as that in the Music Hall, at Cincinnati, it is decidedly objectionable and out of place.

The third position is that known as the advanced reversed position, as found in several of Cavaillé-Coll's important instruments, notably the Organs in Albert Hall, at Sheffield, and the Church of Saint-Sulpice, at Paris. The manual claviers are placed in a console located somewhat in advance of the main body of the Organ; and are reversed, so that the organist sits between them and the Organ, with his face toward the orchestra and audience. The action is carried downward from the keys and underneath the platform on which the organist is seated, into the interior of the instrument. This position is a step in the right direction; and is improved in proportion to the distance the console is advanced from the Organ. The farther away it is, the better the organist will be able to realize and control his tonal effects. It is all-important that he should be able to do so when performing with an orchestra or chorus. Concert-room Organs are frequently employed along with the orchestra in large choral works, concertos, etc.; and they frequently take the place of the orchestra in works of moderate size, or when an orchestra is not available.*

The fourth position is that in which the claviers are placed in a detached console situated between two sections of an Organ. Examples of this position are furnished by the divided Organs in Westminster Abbey, and in the Church of Saint-Vincent de Paul, Paris. In the former, the Organ is divided, and located within and slightly in front of the arches flanking the large choir screen; and the console is located on the screen, toward the south of the center, the organist facing the north section of the Organ. In the Church of Saint-Vincent de Paul, the two sections of the Organ have a space of about fourteen feet between them. The console is placed exactly midway, the organist sitting with his face toward the section which contains the Grand-Orgue, and his back toward the section containing the Positif and Récit expressif. The Pedal Organ is equally divided in the

*One of the greatest treats we ever experienced in connection with organ music was when, on a memorable occasion, the late Mr. W. T. Best rendered the entire orchestral score of Handel's "Theodora," on the Organ in St. George's Hall, Liverpool, accompanying in a truly masterly manner all the vocal solos, choruses, etc.

sections. A more favorable position would have been secured had the console been so placed as to let the organist face the nave. In this and all Cavaillé-Coll's large Organs the pneumatic lever is used in conjunction with a tracker action.

In the four positions above alluded to, a tracker action, with or without the aid of the pneumatic lever, or a tubular-pneumatic action may be employed; but when the claviers are located at a considerable distance from the sound-producing portion of the Organ an electro-pneumatic action becomes a necessity. This action also renders a movable console a simple matter. It is impossible, in connection with Concert-room and large Church Organs, to overestimate the importance and value of a distant or movable console, especially when its locality and distance from the Organ are dictated by acoustical and musical considerations only. Electricity has swept away all difficulties in connection with the position of the console.

Nothing has been said in the preceding paragraphs respecting the compass of the manual claviers; and nothing need be said in the following pages; for the subject is fully considered in the Chapter on The Tablature and Compass of the Organ. Accordingly, we may now proceed to describe the formation of the manual claviers and details connected with their general appointment.

A single manual clavier, as it obtains in a finished instrument, consists of two principal divisions; namely, the key-frame or the framework which supports the keys, which is constructed of oak or some other reliable wood, and has all its parts stationary; and the keys, which are movable, constructed of white pine or some other suitable wood, finished with ivory, ebony, etc. As these portions are formed of several parts which are distinguished, in organ nomenclature, by different terms, it is advisable, for the sake of clearness, to enumerate and briefly describe these separate parts before entering, more or less fully, into practical matters connected with the formation and adjustment of the complete clavier.

Key-frame.—The *cheeks* of the key-frame are the two thick rails, set on edge, which form its sides, and into which the cross rails are inserted and securely fixed. The cheeks are always visible throughout a portion of their length, and accordingly require to be of oak, mahogany, or some other rich wood, carefully and artistically finished adjoining the front or playing portion of the keys.

The *mid-rail* is the part of the key-frame which extends across from cheek to cheek, at their lower edges, and about the center of their length. This rail, also called the *balance-rail* serves as the support or fulcrum on which the keys rock. It is best made of straight-grained oak, but any hard, close-grained wood not liable to warp may be used. The mid-rail holds the *mid-pins*, which pass through the centers of the key bodies, and on which the keys move.

In old Organs the key bodies were commonly pivoted at their rear ends, as in the case of the claviers illustrated by Dom Bedos. In a certain form of electric action, this method of tail-pivoting may be adopted with advantage, a regulating spring attachment being used to impart the required touch to the keys. In this case, the key-frame has a *back-rail* for the reception of the pins, while a mid-rail is required for the support of the electric contacts and the spring attachment above mentioned.

The *bed-rail* is the part of the key-frame which extends across from cheek to cheek, at or near to their front ends, and at their lower edges. This rail holds the *bed-pins*, which retain the keys in position so they shall not rub against each other in their movements; and it also serves to arrest the descent of the keys. The bed-rail is, in claviers of the ordinary form, made of oak or some other hardwood; but in special cases it is of wood strengthened with metal, or altogether of iron or brass. This rail is also designated the *front-rail* to distinguish it from the mid-rail.

The *front-bead* or *cross-bead* is a thin slip of some choice wood, which extends from cheek to cheek, and is screwed to the front edge of the bed-rail, not only to ornamentally finish the same, but to hide the space between the keys and the bed-rail. The front-bead is usually, though not necessarily, made of the same wood as the exposed ornamental ends of the cheeks.

The *thumper*, though held in position by the cheeks, cannot be considered as strictly a part of the key-frame. It is a flat, weighted bar of hardwood, or of metal, covered with thick soft cloth or felt on its lower face, and laid upon the key bodies a short distance behind the black keys. It serves to retain all the keys at the proper level, and to arrest the upward motion of the keys when released by the fingers of the performer. The thumper is so fitted to the cheeks as to have only an upward and downward motion.

THE KEYS—The long quadrangular rod which forms the lever or main portion of a key is termed the *body* or *stock*. It is made of the finest quality of white pine, perfectly straight-grained, and thoroughly seasoned in the open air. Short key bodies have been made of light, straight-grained, mahogany, lime, and certain other suitable woods; but, except under some special conditions, white pine is to be preferred. It is light, easily worked, and when thoroughly seasoned and dried has no tendency to warp or twist. The key body has to be bored, mortised, loaded, and otherwise fitted, as described farther on.

The *combs* are the raised pieces of ebony attached to the playing portions of the shorter key bodies which form the series of sharp keys.

The *platings* are the thin plates of ivory attached to the playing portions of the longer key bodies which form the series of natural keys.

The *nosings* are thin pieces of ivory, celluloid, ebony, or some other choice material,—flat, curved, or molded,—attached to the front ends of the longer key bodies, immediately under the edge of the ivory plating, for the purpose of imparting a highly finished appearance to the clavier.

In the construction of a manual clavier of which the compass, or number of keys, has been decided, the first proceeding is to draw the scale for the entire series of bodies or stocks, and from it prepare and glue together the several pieces of wood required to form the series. For a clavier having a compass of from CC to a^3, comprising thirty-four natural or white keys, the board will measure, across the grain, 2 feet $7\frac{11}{16}$ inches; and for the full organ compass of from CC to c^4, comprising thirty-six natural keys, the board will measure 2 feet $9\frac{1}{2}$ inches. These measurements will allow a space a fraction under $\frac{15}{16}$ inch for each natural key. The scale for the keys is divided accordingly. On examining a properly made

clavier, it will be observed that all the front portions of the white keys are of precisely the same width; while the black keys are slightly narrower than the smaller portions of the white keys which lie between them, accordingly the scale for these parts demands careful setting out.

The clavier scale may be conveniently constructed in the following manner: Take a thin strip of maple or any light-colored hardwood, 3 feet long and about 2 inches wide, dress it smooth, and with a marking-gauge indent a line lengthwise along its center. Then, with a marking-tool and a small square, indent a line across the strip, about 1 inch from one end, and another line at a distance of 2 feet 9½ inches; and accurately divide the distance between the lines into thirty-six equal parts. Commencing from the left, indent a line across the slip at a distance of three parts from the first cross line, as indicated in the accompanying diagram, Fig. LXXVIII., which represents a portion of a manual key scale. The

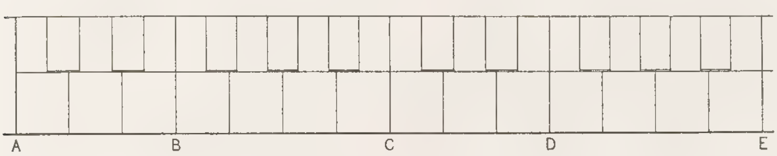


Fig. LXXVIII.

first line is delineated at A, and the line at the distance of three parts from it is indicated at B. Now, at the distance of four parts indent another full cross line, as shown at C; and then add further full cross lines at the alternate distances of three and four parts throughout the remaining extent of the scale. One extra part will be left at the right hand end of the scale, which will be the c^4 key. From the lower edge of the slip to the longitudinal center line, indent the remaining lines which mark off the parts representing the front portions of the thirty-six natural or white keys, as indicated in the diagram. The surface of the slip, between the longitudinal line and the upper edge, has now to be marked off so as to place the black keys in their correct positions with respect to the naturals. To do this, take the distance between the cross lines A and B, deduct two spaces, $\frac{1}{32}$ inch each, for the comb bodies, and divide the remainder of the distance into three equal spaces; then arrange the different spaces alternately as delineated in the diagram, and indent their dividing lines. In like manner, take the longer distance between the cross lines B and C, deduct three spaces, $\frac{1}{32}$ inch each, for the comb bodies, and divide the remainder of the distance into four equal spaces; then arrange the seven spaces so obtained in the manner shown in the diagram. The respective measurements are carried in the same way throughout the scale. When the key bodies are sawn apart, on the lines set out in the above manner, and finished, it will be found that the spaces between and alongside the black keys are slightly wider than the black keys themselves; and this is an advantage to the

performer, allowing his fingers to pass down easily between the raised black keys. When the scale has been divided in the manner directed throughout its length, it should be rendered permanent by having its indented lines distinctly marked with a black-lead pencil, and its surface entirely varnished. In large key-making establishments, scales are formed with projecting steel points, which transfer all the proper divisions to the key plank by being simply laid on, and pressed against, its surface.* This method insures perfect uniformity.

The plank from which the key bodies or stocks are to be sawn has now to be prepared. While the width of this plank will in all cases be dictated by the key scale and, of course, the compass of the clavier; its length, or measurement along its grain, will depend on the clavier in a series, and on the nature of the action immediately connected with the key bodies. The length of the bodies of the natural or white keys will, in the majority of cases, range between 1 foot 6 inches and 2 feet 9 inches. For instance, in the Roosevelt standard claviers (a full size drawing of which is before us as we write†), the length of the bodies of the lower keys is 2 feet 8¾ inches; of those of the middle keys 2 feet ¾ inch; and of those of the upper keys 1 foot 11 inches. Key bodies less than 1 foot 6 inches in length, as found in the upper claviers in the consoles of the larger French Organs, give a somewhat objectionable touch, owing to the extreme inclination the keys assume, especially if the touch exceeds ⅜ of an inch. On the other hand, very long key bodies are to be avoided for several reasons; notably because they are more liable to warp than those of moderate length, and because they have to be of a greater depth than is usually desirable to prevent their springing in action. The finished thickness of the plank, which determines the depth of the key bodies, may vary from ⅞ inch to 1⅛ inches, according to the length of the bodies and the work they will have to do. The latter dimension obtains in the Roosevelt claviers above alluded to.

When all the dimensions have been decided on, the plank has to be carefully built up, and prepared for sawing into the required number of key bodies. To secure the best results the following mode of procedure should be adopted. A board of the very finest white pine, perfectly straight in the grain, and which will finish to the desired thickness, is taken, and from it are cut a sufficient number of lengths to form the complete key plank. These lengths must be of widths sufficient to form the groups of natural keys embraced between any two of the cross lines of the key scale, as marked at A, B, C, D, E, in Fig. LXXVIII., because on these through lines alone the jointings of the key plank should occur, to be ultimately cut along in the process of sawing out the bodies. The edges of the several lengths are planed until the exact widths are obtained, and the whole is glued together, forming a perfectly flat plank. When dry, the front edge of the plank is dressed for the reception of the wood nosing piece. This nosing piece is best made of holly when it is to be veneered with thin ivory or celluloid; and is securely glued to the end grain of the key plank. Further details of the key nos-

*Transferring scales of this description are used in the key department of Messrs. Steinway & Sons' immense Piano Manufactory, at Steinway, Long Island.

† This drawing is reproduced in the Chapter on The Manual Couplers.

ings are given later on. The key plank is now dressed to the finished thickness, and its side and back edges are dressed straight and square, leaving it of the exact width and length required. The upper surface of the plank has now to be accurately divided and marked for the key bodies. Reference to the accompanying diagram, Fig. LXXIX., will aid the reader in understanding how this is accomplished. Five parallel longitudinal lines have first to be drawn. The line A—B determines the front ends of the sharp keys; and should be drawn so as to be 2 inches from the front edge of the white or natural keys when finished with the ivory plating, which projects slightly from the face of the finished nosing. The

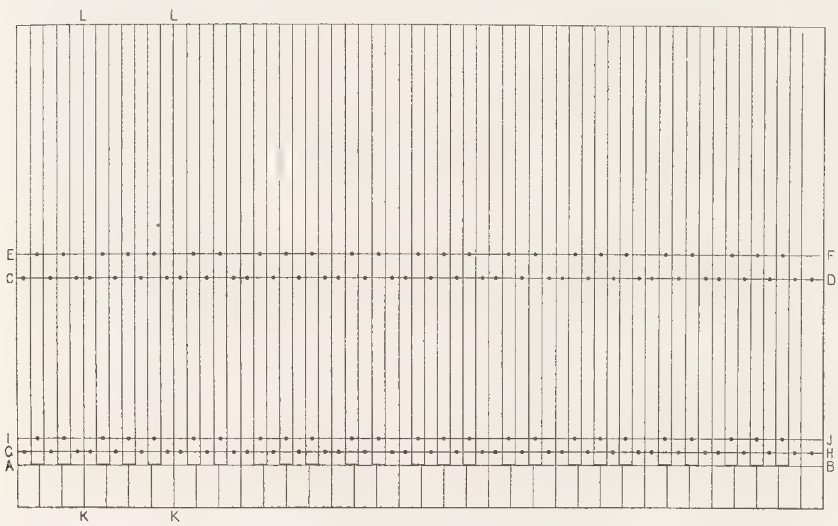


Fig. LXXIX.

lines C—D and E—F mark the positions for the mid-pins, which should be about 1 inch apart, and placed at, or near to, the center of the respective key bodies. The most desirable positions for these fulcrum pins depend on the nature of the key action. The remaining lines, G—H and I—J, mark the positions for the bed-pins in the natural and sharp keys in claviers of the overhanging pattern. In claviers that do not overhang, the bed-pins of the natural keys may be placed in front of the sharp keys, as shown in Fig. LXXXV. It is always desirable to locate the front or bed-pins as close to the ends of the natural and sharp keys as practicable. In the case of the sharp keys there is of course no difficulty in placing them quite close; but in the several forms of overhanging claviers, the pins require to be placed at varying distances from the nosings of the natural keys. When the keys overhang considerably, some makers plant the pins for both the naturals and sharps in a single straight row; but this is neither necessary nor desirable; for

when the pins for the natural keys have to be placed so far inward as to render the single row possible, it will be quite right to place the pins for the sharp keys a reasonable distance from their ends, so as to be able to plant all the pins in two rows. It is always desirable, in matters of this class, to have as little inequality as possible between different parts. The depth of the touch in both the natural and sharp keys must be correctly adjusted at the bed-pins, by using proper thicknesses of felt, or by adopting any other satisfactory method.

The numerous transverse lines, derived from the key scale previously described, which mark the divisions of the key bodies, have to be accurately drawn on the plank, as shown in Fig. LXXIX. It will be observed that the lines marked

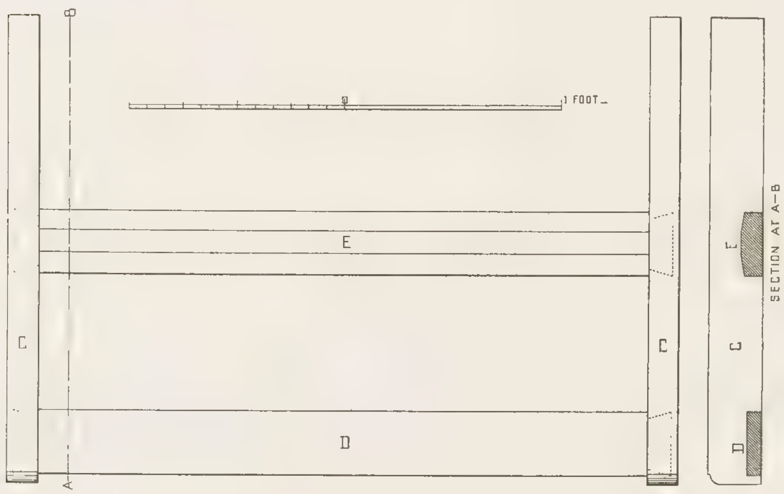


FIG. LXXX.

K—L are carried the entire length of the natural bodies, while all the other lines stop at the line A—B. When all the lines and pin centers are drawn and marked, the plank is ready to be placed in the key-frame to be drilled, so soon as the latter is constructed in accordance with the key arrangement.

The cheeks of the key-frame, which, as already said, may be of oak, mahogany, or other choice wood, are formed of single pieces, slightly longer than the natural key bodies, so as to finish a short distance in front of the cross-bead, or in advance of the key platings in projecting claviers. The depth of the cheeks will of necessity be dictated by the vertical distance between the playing surfaces of the associated claviers, and will accordingly range between 2½ inches and 3 inches; and their thickness may range between 1⅜ inches and 1⅞ inches. Thick cheeks, when properly treated, have a handsome appearance. The distance at which the cheeks

are held apart by the bed-rail and mid-rail is determined by the key plank already described. This plank should lie between the cheeks with about $\frac{1}{20}$ inch free space at each end. The bed-rail is a piece of straight-grained oak or mahogany, usually about ⅞ of an inch thick and from 3 to 3½ inches wide: its upper surface may have an inclination downward toward the front to accord with that of the key when depressed. The mid-rail is also a piece of straight-grained oak or mahogany, about 1⅛ inches thick and 3½ wide: its upper surface is splayed to allow the keys to rock properly upon it. Both the bed-rail and mid-rail are firmly tenoned or dovetailed into the cheeks; their positions being determined by the lines of the bed-pins and mid-pins; the position of the bed-rail being also influenced by the form of the fronts of the keys. In Fig. LXXX., are given a Plan or Top View and Section of the key-frame as above described. The cheeks are shown at C, the bed-rail at D, and the mid-rail at E. The exact positions of the two rails with relation to the cheeks, and also their forms, in cross section, are shown in the Section at A—B. At this stage the frame is ready to receive the key plank, for the purpose of being drilled for the bed-pins and mid-pins. The key plank, with its marked side uppermost, is adjusted in the frame, exactly in the position the keys will occupy when finished, and securely wedged between the cheeks, or fixed in any convenient way. As the key plank must be held horizontally while being drilled, it should be supported by a thin strip of wood where it extends over the bed-rail. The frame and key plank are now placed in a vertical drilling machine and by means of drills of special form the holes for the mid-pins and the bed-pins are made through the key plank and into the mid-rail and bed-rail. By this simple means the exact position of every key body is secured when the plank is sawn. The drills used cut holes of two sizes at the same time, and are so adjusted as to descend to the required depth only, securing perfect uniformity in their work. In

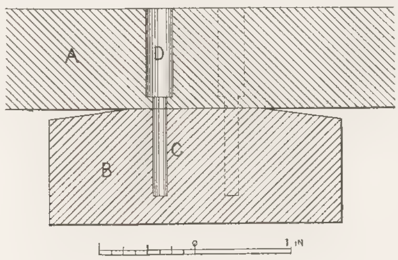


Fig. LXXXI.

Fig. LXXXI., which represents a Section through the key plank and mid-rail, the form of the holes for the mid-pins is shown. A is the key plank or a key body, and B is the mid-rail. The smaller hole, C, is for the reception of the mid-pin, which is tightly driven into the mid-rail, while the larger hole, D, is required to allow the key body to rock on the mid-pin. The smaller hole which extends from D to the

under side of the key body, holds the key in position on the mid-pin, while it allows the necessary rocking motion of the key. The holes for the bed-pins are drilled in a somewhat similar manner; the larger holes extending entirely through the key plank, sufficient in diameter to allow for the thick bushing-cloth, applied subsequently to the sides of the slots here formed. When all the necessary holes have been drilled, the key plank is removed from the frame.

The key-frame is now advanced toward completion by having its bed-pins and mid-pins driven into their respective holes. The mid-pins are straight pieces of hard white metal or phosphor bronze, plated with silver, $\frac{3}{32}$ inch in diameter and $2\frac{1}{4}$ inches long. These are driven about $\frac{3}{4}$ inch into the mid-rail, and adjusted where required so as to stand perfectly vertical. The bed-pins, in all properly constructed claviers, are now of the oval or "cricket-bat" form, as represented in Fig. LXXXII. full size. The lower part, at A, is round, and is that which is driven into the bed-rail: the upper part, B, is oval, and is that on which the key moves. The advantage of the oval pin over the ordinary round pin is that it can be slightly turned when a key becomes loose, through the wearing of the bushing of its pin slot. Unpleasant rattling is thus prevented. The diameter of the cylindrical part of the pin is $\frac{1}{8}$ inch, and its length is $\frac{5}{8}$ inch; while the oval part is 1 inch long and measures $\frac{1}{8}$ inch by $\frac{3}{16}$ inch. The pin is turned in any desired direction by means of a properly fitting key, and a perfect adjustment is readily obtained. The bed-pins are driven into the holes in the bed-rail until their oval parts touch its surface, with their greater diameter on the center lines of the key bodies. The key-frame is now ready to receive its front-bead, and to be otherwise finished. Small vertical grooves must be cut in the inside of the cheeks, from their top edges downward about $1\frac{1}{2}$ inches, to receive the metal pins in the ends of the thumper, which hold it in position while allowing it to rise or fall as required by the touch adjustment.

Fig. LXXXII.

When two or more claviers are associated together, their respective cheeks have dowel holes and dowels for the purpose of holding them together in their proper relative positions. Each cheek should have a dowel near each end; and a sunk hole in its center, through which it is screwed to the key bed or to the cheek of the key-frame below. In claviers constructed for certain forms of the electro-pneumatic action, the cheeks of the different key-frames are hinged together at their rear ends instead of being rigidly screwed down. This is a very convenient arrangement when the electric contacts are located immediately under and toward the front of the key bodies, as it admits of the different claviers being lifted up for any necessary repairs or re-adjustment of the contact system without in any way disarranging the general action, or requiring the removal of any portion of the console. In the beautiful and complete detached electric consoles constructed by MM. Casavant Frères, of St. Hyacinthe, Canada, the claviers are hinged in this convenient manner.

The thumper may be made of either wood or metal, according to the space there is between the upper surface of the key bodies and the top edge of the

cheeks when the keys are on touch. When of wood, the thumper should be made of perfectly seasoned straight-grained oak or mahogany, about 3 inches wide by 5/8 inch thick. The thickness will, however, be dictated by the depth or space available. The thumper must be dressed perfectly flat on its under side, which is to be covered with thick cloth or fine felt, and be brought to the necessary length to lie freely between the cheeks of the key-frame. Brass pins should be driven into the center of its ends, to rest in the grooves in the cheeks, as above mentioned. The thumper should be divided into six or eight parts; and in the centers of these parts holes about 1 1/4 inches in diameter should be bored through its thickness; and into these holes melted lead should be poured until they are completely filled, the thumper resting the while on a level stone or iron surface. When the lead is cold it should be hammered so as to make it perfectly tight in the holes, and then planed level with the surface of the wood. This lead is required to give the thumper the weight necessary to withstand the upward thump of any number of keys that may be released at the same instant. In addition to this a certain

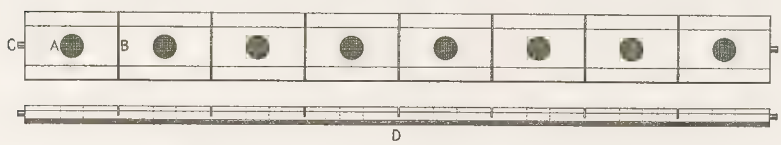


Fig. LXXXIII.

degree of flexibility is requisite, and this is secured by making fine saw cuts across the upper side of the thumper, midway between the lead plugs, and downward to about 3/16 inch from its under side. Top and Side Views of the finished thumper are given in Fig. LXXXIII. The lead plugs are indicated at A; the transverse saw cuts at B; the guide or holding pins, which enter the vertical grooves in the cheeks of the key-frame, at C; and the felt or cloth covering, against which the keys strike, at D. A very satisfactory thumper is made of ordinary pipe metal. It is cast as a strip, a little larger each way than the necessary finished dimensions, and then planed on all sides until the proper weight is obtained. Felt is cemented to its under surface and trimmed to its edges. A thumper so formed has all the necessary requirements, and is very suitable in the case of claviers with contracted levels.

Before returning to the description of the process of key-making, we may touch on some remaining matters connected with the key-frame. When the claviers are brought closer together than 3 inches it is necessary to considerably reduce the thickness of both the bed-rail and mid-rail, while it is equally necessary that their rigidity should not be impaired. When the reduction in thickness is slight, the rails may be stiffened by being increased in width; but when their thickness is much reduced, they should be rendered rigid by having strips of steel

securely screwed along their vertical sides. The bed-rail will only require a strip on its inner side or edge. Metal rails have been sometimes used, but there is, under all ordinary circumstances, no necessity to resort to them, indeed, they are not to be recommended.*

The form and size of the cross-bead or front-bead are dictated by the treatment of the front end or nosing of the keys. It is usually a strip of wood, about ¼ inch thick, molded on its upper edge, and screwed to the front edge of the bed-rail. When set behind the nosing of the keys, as it sometimes is in overhanging claviers, it is a plain strip of wood about $\frac{3}{16}$ inch thick. Both forms of the cross-bead are shown in our illustrations of the different forms of claviers.

It is very desirable that all the visible parts connected with the claviers of an Organ should be beautiful as well as useful; and the parts which most prominently present themselves for artistic treatment are the front portions of the cheeks of the frame which flank the keys. Two methods of ornamentation are suitable: First, by imparting an appropriate and graceful form or contour to the ends of the cheeks, and subsequently staining and French-polishing them. Secondly, by casing or veneering the cheeks with very choice wood, molding their edges, and inlaying their flat surfaces. The latter method of ornamentation will, except in very rare cases, be followed only in the adornment of the highest class of Chamber Organs, which are called upon to be handsome pieces of art furniture as well as perfect musical instruments. In the first method, the contours of the cheek ends will be dictated largely by the forms and relative positions of the playing portions of the claviers between them; for contours perfectly suitable for overhanging or projecting claviers may not be applicable to plain square stepped ones. As any design, within certain limits, can be adopted that taste or fancy may dictate, it is unnecessary for us to give anything beyond a few suggestions on the subject. When the claviers are placed about 3 inches apart, the cheeks, which will be of a corresponding depth, may have whatever contours are desired cut in their ends, without requiring any addition to be made to their depth there. But when the claviers are so constructed as to come much closer together, the cheeks of one or more of their frames will require to have additional pieces glued to their upper edges, so as to raise them above the level of the keys. These matters are fully described farther on. Some organ builders are content to leave the ends of the cheeks perfectly plain and square; but this treatment has a mean and unfinished appearance, unless very choice wood is used, additional thickness is given to the cheeks, and they are relieved by inlaid lines and simple geometrical patterns in contrasting materials. Other builders use square ends with their upper corners slightly rounded or molded. This treatment also calls for choice materials to cover its baldness. Without resorting to casing, veneering, and inlaying, very

* In the year 1873 an English Patent was taken out by Mr. Thornelow, Organ Builder, for an invention, in which three manual claviers are brought so close together that the under edge of the nosing of the second row of keys is only slightly above the plating of the first row, and the under edge of the nosing of the third row bears a similar relation to the plating of the second row. This arrangement compels the adoption of thin metal bed-rails, under the second and third claviers, to the front edges of which the bed-pins are soldered. This invention also embraces a special system of manual coupling. Specification, No. 402, dated February 3, 1873.

artistic results can be obtained by giving the ends of the cheeks contours which combine or harmonize with each other; that is, forming one continuous design, or a series of separate or repeating designs which produce a pleasing effect. As there will in all cases be horizontal dry joints between the superposed cheeks, the designs must be made with due regard to them. In the cheeks of those claviers which are brought close together, there will be both horizontal and vertical dry joints which must be recognized. In the accompanying illustration, Fig. LXXXIV., some suggestive treatments are given, in which the relative positions of the claviers are indicated by dotted lines. It may be mentioned at this point that when an organ-case is designed in any strict style of architecture, such as Greek, Gothic, or any form of Renaissance, the treatment of the key-case should accord in all its ornamental details.

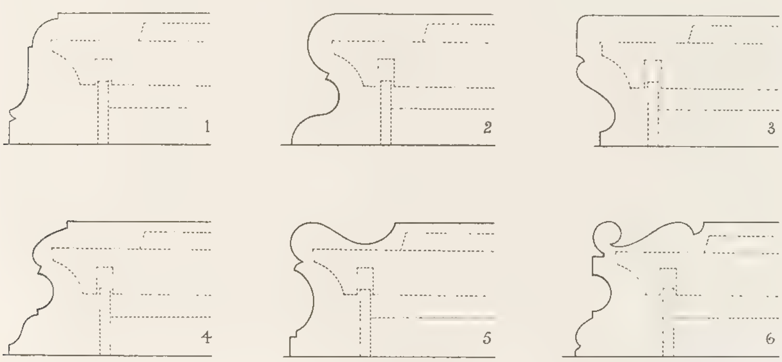


Fig. LXXXIV.

When the displayed portions of the cheeks are cased or veneered as before mentioned, the best woods for the purpose are ebony and rosewood. To contrast with these, inlays of ivory, mother-of-pearl, satinwood, or holly, should be used. The most refined effect is produced by ebony inlaid with ivory, because these correspond with the materials of the keys. In all cases the cross-beads and other finishings of the key-case must accord in style and materials with the cheeks.

We now return to the formation of the keys, which we left in the plank form, immediately after having been drilled for the mid-pins and bed-pins, and removed from the key-frame. The first proceeding, at this stage, is to cut oblong slots (from the under side of the key plank) through the plank, accurately centered to the holes drilled for the bed-pins. This is readily accomplished by a special vertical slotting tool guided by the drilled holes. The slots should be ⅜ inch long and ¼ inch wide, or just sufficiently wide to receive the bushing-cloth and the cricket-bat pin in its narrowest way. The plank is now turned marked side uppermost, and a channel, about ¾ inch wide by ⅛ inch deep, is formed throughout its entire width,

immediately over the bed-pin slots of the natural keys. This is done by a grooving-plane. The channel is filled with a strip of clean white pine, with the grain running across it, to correspond with the wood and grain of the plank, securely glued in, and ultimately dressed off flush with the surface of the plank. This strip prevents the dark looking slots from showing through and discoloring the ivory plating.

The front edge of the plank is now prepared for the completion of the nosing of the keys, and the thin plates of ivory, celluloid, or other material, are securely glued on; care being taken to joint the ends of the plates exactly where the saw will enter between any two keys. When ivory is employed the plates are usually four keys long. In very high class work, ivory covers all the exposed ends of the keys, even when they have a considerable projection in front of the cross-bead; while in other cases, merely the extreme, shallow ends of the keys are covered with ivory; the under side of the overhanging portion, thence to the cross-bead, being the nosing wood simply French-polished, or stained some dark tint and polished, as taste may direct. When the nosing is finished, so far as the application of ivory, celluloid, or other materials are concerned, and all is perfectly dry, its upper and lower edges are carefully dressed level with the surfaces of the plank, which is now ready to receive the ivory platings of the natural keys. The ivory for this purpose is supplied to the key maker in pieces of the proper dimensions, two pieces being required for each key; namely, a wide piece for the front portion and a narrow piece for the portion which extends between the black keys. Before the ivory is glued to the key plank it should be thoroughly dried, by being set on edge between pins, on a wooden tray, so that the air can act equally on both sides, and exposed to dry air at a temperature of about 130° Fahrenheit for two or three days.* The key plank, from the nosing back to where the ivory plating extends, is gone over with a very fine toothing-plane, and this toothed surface is coated with thin glue in which a little zinc white is mixed, to form a clean bed for the ivory. A slip of wood is tacked down to the plank, with its straight edge against the longitudinal line which marks the ends of the comb stocks, as indicated at A—B, Fig. LXXIX; this is to guide the placing of the ivory platings while being glued on. The ivory plates for the wider parts of the keys, having been finely toothed on their under surfaces, brought to the required width, and accurately squared, are quickly laid in position, on a thin coating of the finest white glue, and pressed tightly against the straight slip. Any glue that may appear on the upper surface of the ivory is wiped off, and the slip of wood is removed. The platings are now covered with a strip of cloth on which is laid a warm bar of iron; and pressure is applied, by any convenient means, sufficient to secure a perfect junction between the platings and the key plank. When the glue has become perfectly set, the bar and cloth are removed, and the ivories are wiped with a sponge or cloth dipped in hot water to remove any glue that may have been pressed out at their edges. After all has become thoroughly dry, the edge of the platings, which rested against the wooden strip, is shot perfectly straight and square with a narrow

* This practice is invariably followed in Messrs. Steinway & Sons' piano manufactory.

iron plane. This plane has a diagonal iron, set accurately to one of its sharp edges, so as to cut the edge of the ivory without touching the surface of the key plank upon which it is held flat while being used. It is absolutely essential that the edge of the ivory be dressed square and true, so as to secure an invisible joint between the wide and narrow portions of the platings.

The narrow portions of the platings which extend between the black keys are attached in the following manner: The ivories are finely toothed on their under surfaces, and their ends, which fit against the portions already fixed (as above described), are cut perfectly straight and squared in a small shooting-block fitted with an iron edging-plane. These pieces are laid in order and position on the surface of the key plank; and at the free end of each, and slightly within its length, a small hole is bored into the plank for the reception of a wooden peg which is glued and driven in. This peg is for the purpose of holding the narrow piece of ivory tightly against the dressed edge of the plating already glued on; the ivory being sprung into its place between the pin and the plating while being glued down. The method of gluing and pressing is in all essentials similar to that previously described; care being taken to prevent any glue finding its way between the dressed edges of the ivories, otherwise the jointings would become visible. When all has been successfully accomplished and the work is dry, the platings and the adjoining surface of the plank are cleaned with a sponge or cloth dipped in hot water. The entire ivory plating is now ready to undergo the first finishing process. The front edge is carefully planed true, and left projecting about $\frac{1}{20}$ inch in advance of the front nosing; then it is slightly rounded. The surface of the plating is now carefully scraped, and gone over with pieces of finest glass paper that have been previously "killed" by being rubbed lightly together. At this stage the plating is left until the keys are sawn out.

We have described the usual method of plating the keys; but when very high class work is desired, the ivory for each key should be in one piece and about $\frac{1}{10}$ inch thick. While the ivory is more expensive, much less time is expended in fitting and gluing it to the key plank. When an Organ is to be very often played upon we strongly advise the adoption of this method of plating.

The key plank, marked, drilled, nosed, and plated, as above described, has now to be sawn into separate keys. This is done by a fine band-saw, the plank being carried on a sliding bed, or against a rest, which secures perfectly straight and square, parallel cuts along the transverse lines that divide the key bodies. The dividing lines between the keys C and D, D and E, F and G, G and A, and A and B, are sawn first. These are the short lines which extend from the nosing back to the extent of the broad or front portions of the ivory platings; that is, to the line A—B, in Fig. LXXIX., where the playing ends of the comb bodies come. The plank is now turned, with its other edge toward the saw, and all the transverse lines, except those between the keys B and C, and E and F, are sawn forward to the line A—B above mentioned. The plank is again turned, with its nosing toward the saw, and the through transverse lines, between the notes B and C, and E and F are cut, separating the plank into five pieces of five keys each; five pieces of seven keys each, and the odd key, c^4. These pieces are cut across

the front ends of the comb bodies by means of a very narrow fret-saw; it being passed down the long saw cuts and turned sharply along the back edges of the wide parts of the ivory platings. These last cuts separate all the key bodies from each other. To prevent any mistakes the keys should be laid in their original order and numbered from left to right. The sides of the key bodies are now dressed with a fine iron plane, or spoke-shave, just sufficiently to remove the saw-marks; and the ends of the comb bodies are carefully squared, and made ready to receive the ebony combs or sharps. The wood at the inner ends of the broad ivory platings of the natural keys is splayed slightly downward from the edge of the platings, so as to prevent the black keys touching the natural keys when put down. The Side View of the playing ends of both a natural and a sharp key, given in Fig. LXXXV., shows this splaying, and the correct position of the two keys with

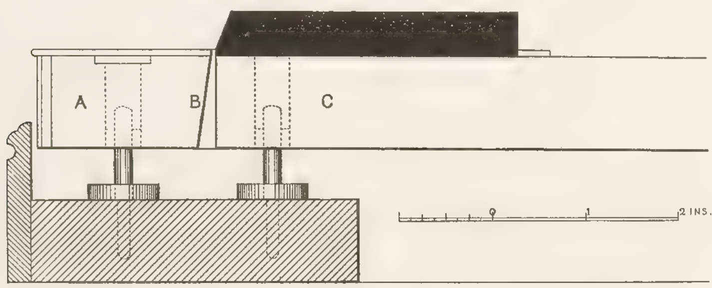


FIG. LXXXV.

respect to each other. The wide end of the natural key body, with its nosing and ivory plating, is shown at A, while its splay is indicated at B. C is the end of the sharp key body, carrying the ebony playing portion of the key.

At this stage the key bodies may be finished so far as their adjustment to the mid-pins and bed-pins is concerned. With respect to the latter, the slots formed at the playing ends of the key bodies have only to be covered on their sides with narrow strips of French bushing-cloth, against which the cricket-bat pins rest. We may remark here that when the claviers are likely to be subjected to the action of moist air, it will be advisable to omit the cloth bushing which would be liable to absorb the moisture and impede the free motion of the keys. In this case, the slots for the bed-pins should be accurately cut in thin pieces of straight-grained hardwood attached to the under edge of the keys. The sides of the slots must be filed perfectly smooth and then black-leaded to prevent friction. The holes drilled in the key bodies for the mid-pins are finished in the following manner: The holes which form the hinges of the keys are slightly countersunk on the under side of the bodies, and made to move easily on the mid-pins, so that the keys can rock perfectly. On the upper surface of the bodies, immediately over the holes drilled for the mid-pins, are glued pieces of basswood or some other close-grained wood,

about 2 inches long and ¼ inch thick, in each one of which a slot ¼ inch wide by ⅜ inch long has been cut and lined with bushing-cloth. These pieces (called by piano key makers, *buttons*) are adjusted so that the mid-pins pass through their slots and support the key bodies accurately at right angles to the bed-rail. The slots, while preventing any lateral motion, allow the keys to rock easily. In common work, the slots in the buttons are cut so as to accurately fit the mid-pins and have no cloth bushing. This method is not to be recommended, except for claviers that are likely to be subjected to the action of moist air. When the bushing is omitted, the sides of the slots in contact with the pins must be carefully smoothed and black-leaded. Sections through a key stock, showing the proper treatment at the mid-pins, are given in Fig. LXXXVI. A Longitudinal Section is shown at A, and a Transverse Section at B.

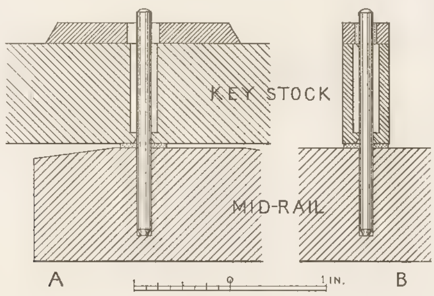


Fig. LXXXVI.

The platings of the natural keys are now finished by having their side edges and front corners slightly rounded, so as to be agreeable to the fingers in playing, and their surfaces finely smoothed with powdered pumice-stone, and polished with precipitated chalk and water.

The ebony for the combs or sharp keys is sawn into pieces a little larger than the finished dimensions, and thoroughly dried in a hot-air chamber. Perfect pieces are then taken and planed to the exact depth required, ½ inch, and to a little in excess of the finished width. The length of the combs vary from 3 inches to 3½ inches, according to the arrangement of the claviers. The former length is that advocated and specified by the late Mr. W. T. Best, and may, accordingly, be accepted as sufficient by the most exacting performer. When more than two rows of keys are used, it is clearly desirable to adopt the shorter combs, bringing all the claviers within easy reach of the player: it is absolutely necessary when four or five rows are associated together. The pieces of ebony, dressed as above described, are now laid side by side on a wooden tray which allows the front ends of the combs to project slightly beyond its edge, the other edge having a ledge against which the back ends of the combs rest. The pieces of ebony are wedged tightly together between the ledges at the ends of the tray. Held together in this

convenient manner, the fronts of the combs are dressed to the proper slope; and their upper surfaces are scraped and prepared for staining and French polishing. Staining is necessary to remove the numerous grey markings which are common in all ebony. When the polishing has been finished and become perfectly hard, the combs are removed from the tray, and their sides are carefully planed to the required inclination. This is done in a planing-block, having right and left sloping surfaces, in which are channels to hold the combs exactly in the right positions while their sides are being planed level with the block. This method secures accuracy of form and perfect uniformity in dimensions. The combs are finished by having their top front corners rounded off by a machine constructed for the purpose; and their sloping sides smoothed with the finest glass-paper, and rubbed with the black stain where necessary. The combs are now toothed on their under surface and securely glued to the key bodies, practically completing the keys.

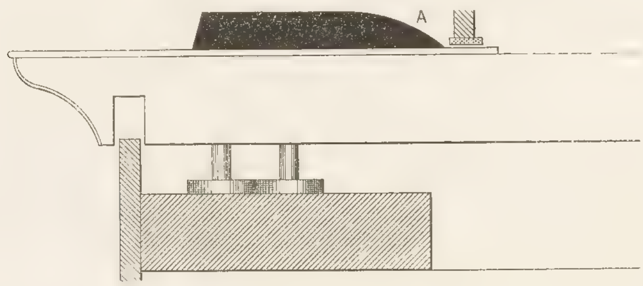


Fig. LXXXVII.

In Fig. LXXXV. the usual, and in our opinion the best, form of the ebony combs is shown, but certain enterprising organ builders have adopted a shape which seems to have little to recommend it. Whatever practical value may be claimed for it, we unhesitatingly pronounce it extremely ugly. The form alluded to is given in the accompanying illustration, Fig. LXXXVII. It will be observed that instead of having a straight upper surface, as in all piano keys, the comb is cut away, in a convex curve, in its rear portion, at A. When sharps of this form are depressed unsightly gaps are displayed between the narrow ivory platings of the contiguous natural keys. An attempt to give an ornamental appearance to the sharp keys, in Chamber Organ claviers, has been made in England. The keys are formed of side pieces of ebony glued to a center layer of ivory about ⅛ inch thick. The playing surface of the sharps have, accordingly, a striped appearance, imparting a somewhat disturbed effect to the clavier.

Some key makers vary the order and certain details of the processes we have described; and sometimes they materially modify them with the view of saving labor and expense. With such undesirable modifications we have no sympathy and need not enter on their consideration here.

The finished keys are placed on their pins in the key-frame, and carefully adjusted so as to move easily, without any lateral motion, and present a perfectly even appearance. Small discs of cloth or thin felt are placed between the keys and the mid-rail, being punched with holes for the mid-pins; and discs of thick, soft felt, punched with holes, are placed round the bed-pins to receive the downward thump of the keys in playing.

We may now say a few words regarding the centring and loading of the keys, before we pass on to the consideration of several special and important details which have not been discussed in the preceding pages.

By centring is meant the proper placing of the mid-pins between the front ends and the tails or back ends of the keys. The natural position is exactly in the center between these extremities, and it should not be departed from except on sufficient grounds. As the keys should fall 3/8 inch, and under all ordinary circumstances should not exceed that fall, there rarely need be any necessity for the mid-pins to be moved from the central position. When the key action is of the ordinary tracker class, there will be no positive call to increase the movement; for it is sufficient, in properly constructed wind-chests, for the pallets to be drawn down 3/8 inch at the points where their pull-down wires are connected. Should, however, a slight increase of movement be deemed advisable in the pallets, the increase should be gained at the key tails, by moving the positions of the mid-pins from the centers of the keys to points nearer their playing ends. A gain of 1/8 inch may by this means be safely obtained for the action. When the pneumatic lever is introduced, or when tubular-pneumatic or electro-pneumatic actions are employed, in which the pneumatic valves or electric contacts are actuated at the tails of the keys, it may be desirable to correctly balance the key bodies, while it is not invariably necessary that they should be so treated. When the electric contacts are located somewhere between the bed-pins and the mid-pins, the latter pins may pass through the key bodies at any convenient position in their length, or even at their rear ends. The position of the mid-pins for the longer or natural keys having been decided; the mid-pins for the shorter or chromatic keys must be so placed as to secure the same rise and fall in the key tails as obtain in the tails of the longer or natural keys. The touch of both classes of keys must also be exactly the same.

When two or more claviers are associated together, it is most desirable that the movements of all should be similar. This is essential when unison couplers, of a mechanical character, are inserted between the claviers; otherwise the keys actuated by the couplers will be lifted too high at their tails, or not high enough. At the points where such couplers bear between two claviers, the movements of the key bodies must be exactly the same. This must be carefully calculated in centring the different claviers.

When the keys have their mid-pins in the central position, the ivory plating and nosing and the ebony combs impart the weight desirable, under certain circumstances, to their playing ends: but there are occasions when, through peculiarities in the key action and couplers, it is necessary to add weight to one end or the other of the key bodies. This is called loading the keys; and simply consists in inserting slightly tapered, round plugs of lead, about 3/8 inch in diameter, into holes

bored through the sides of the key bodies, where required to impart the necessary weight. When the plugs are driven tightly into the holes, their ends are planed level with the sides of the key bodies. No directions can be given respecting the positions or number of the loadings, as they entirely depend upon, and are dictated by, the character of the key action employed and the manner in which it is connected with the key tails. In electric actions, in which the manual keys have simply to make electrical contacts, springs of some form—preferably spiral and readily adjustable—are used instead of loadings. The springs act under or over the key bodies according to the locality of the contact action. The springs give the necessary weight or resistance to the manual touch; and when they are adjustable, any weight and perfect regularity can be imparted to the touch.

We may now enter on the consideration of some important matters connected with the front or playing portions of the claviers when they are arranged in groups of two, three, four, and five. When two claviers are associated together—usually commanding the Great and Swell Organs—the only treatment called for, of a special character, is that which places them sufficiently close together to enable the organist to perform on both claviers, with the thumb and fingers of one hand,

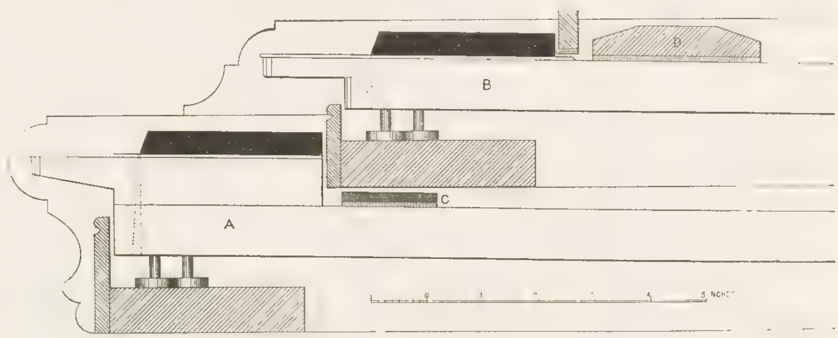


Fig. LXXXVIII.

in the manner pointed out in the opening portion of the present Chapter. This desirable end can be attained in two ways: First, by so constructing one of the claviers that its playing portion shall be brought nearer to the level of that of the other clavier than is practicable under the ordinary mode of construction. Secondly, by simply advancing the upper clavier so as to overhang the lower one as far as practicable without rendering it inconvenient to manipulate the latter. The first treatment is exemplified in the accompanying illustration, Fig. LXXXVIII., in which is shown what is known as the "bayonet key," a shape which has been adopted on special occasions by several organ builders. The bayonet key is represented in the lower clavier at A. It is formed by the addition of a piece, securely glued to the upper surface of the straight key body, on which the ivory

plating of the natural key, or the ebony of the sharp key, is laid in the manner already described. The key of the upper clavier, B, is of the usual straight form, treated so as to slightly overhang the bayonet key. By this arrangement the claviers can have their levels brought very close together. In the illustration the distance between their playing surfaces is 1¾ inches. This distance can be further reduced by increasing the depth of the bayonet key, and having no projection beyond the cross-bead in the upper clavier. The thumper of the lower clavier, C, requires to be thin, and should be made of a flat bar or plate of iron, about 3/16 inch thick and from 1 inch to 2 inches wide, as the clavier may require. It should be japanned to prevent its rusting, and covered on its surface next the keys with felt, as indicated. The thumper of the upper clavier may also be of iron, or of loaded wood, as previously described, and as indicated at D. As the construction of the bayonet key adds a considerable weight to its playing end, it will in all probability have to be loaded beyond its mid-pin to obtain the proper balance.

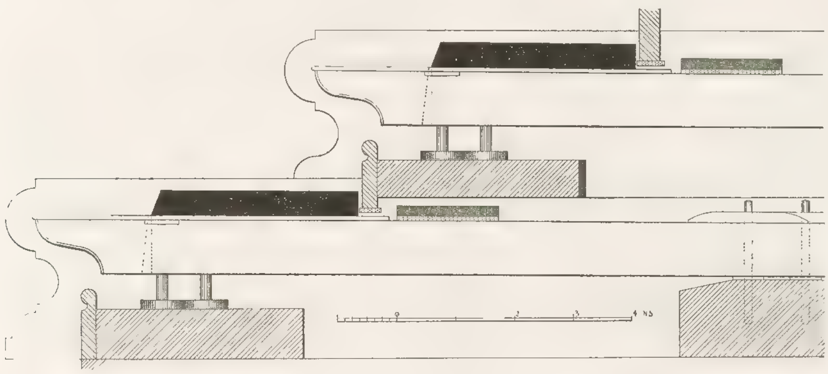


FIG. LXXXIX.

Claviers can be constructed with their ivory plating from 2½ inches to 2¼ inches apart, without resorting to the bayonet form of key, in the manner shown in Fig. LXXXIX. The claviers are in this instance placed 2½ inches apart. An iron thumper, similar to that above described, is used for the lower clavier. By repeating the treatment of the upper clavier, and using iron thumpers, three or four rows of keys may be conveniently put together. An example of a similar treatment obtains in the four manuals of the Organ in Derry Cathedral, built by Messrs. P. Conacher and Company, of Huddersfield. In these claviers the cross-beads have been omitted. Other organ builders follow the objectionable practice of omitting the front-beads in their claviers, showing the naked bed-rails, bed-pins, felts, etc., and imparting a very unfinished and slovenly aspect in their work, as well as furnishing ample lodgements for dust and fluff that are only too evident and always unsightly.

In the illustration, Fig. XC., is shown an arrangement of three overhanging claviers which has a handsome appearance in work. It differs from those previously illustrated in the manner in which the natural keys extend, in their full depth, in advance of the front-beads, being so cut as to allow them to embrace the beads, as indicated at A, A. The claviers are placed at the maximum distance of 3 inches; and the nosings of the claviers C and D are so formed as to interfere in no way with the action of the performer's hands. The curved portions may be veneered with white celluloid or with ebony, the latter having a good appearance in contrast with the ivory plating. For less expensive work black enamel paint may be used, these parts being subjected to no wear. The lowest clavier, B, has

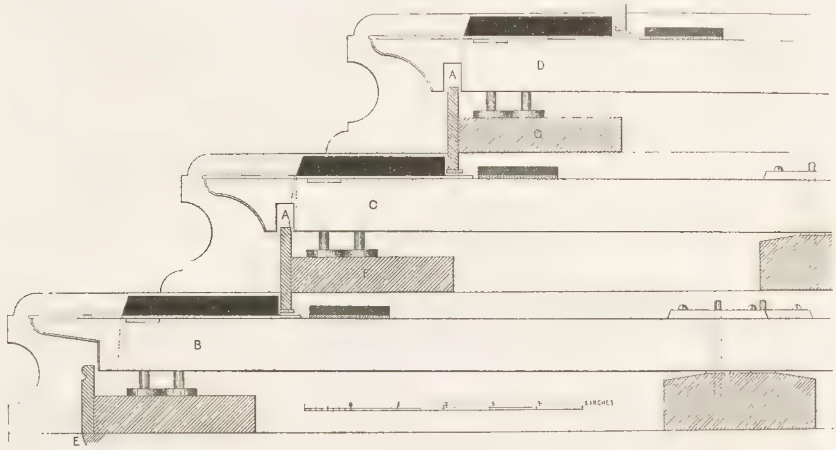


Fig. XC.

also a projecting nosing, partly for the sake of uniformity, and partly to favor a more direct view of the pedal clavier below, the key-bed being cut away to the face of the front-bead, at E, between the cheeks of the key-frame. In this arrangement, the vertical distance between the ivory platings of the lowest and highest claviers is 6 inches, and the horizontal distance from the nosing of the lowest clavier to the back of the ebony sharps of the highest clavier is only 12½ inches. By making the key bodies C and D 1 inch deep, and reducing the bed-rails F and G ⅛ inch, the claviers can be brought ¼ inch closer to each other. This reduction is to be recommended when a fourth clavier is added.

When thumb pistons or touches are placed between the manual claviers, a very slight projection can be given to the keys beyond the face of the front-beads, especially as it is undesirable to project the pistons to any great extent. When pistons or touches of any description become important features, the old arrangement of the claviers, in which the keys do not project in advance of the front-beads,

appears to have something to recommend it. This arrangement is shown in Fig. XCI., but is one that is never likely to be adopted by English or American organ builders in this year of Grace. The objections to this arrangement are: First, it renders the playing of two adjacent claviers by one hand extremely difficult, if not practically impossible. Secondly, it throws the higher claviers, in groups of four and five, too far from the performer. In a group of four claviers, the distance from the nosing of the lowest clavier back to the far end of the ebony sharps of the top clavier, even when the shortest desirable keys are used, cannot well be less than 20¾ inches; while in the case of five claviers, the corresponding measurement will be about 26 inches, a most inconvenient stretch for the performer's arms. While the old style claviers may be suitable for the convenient location of

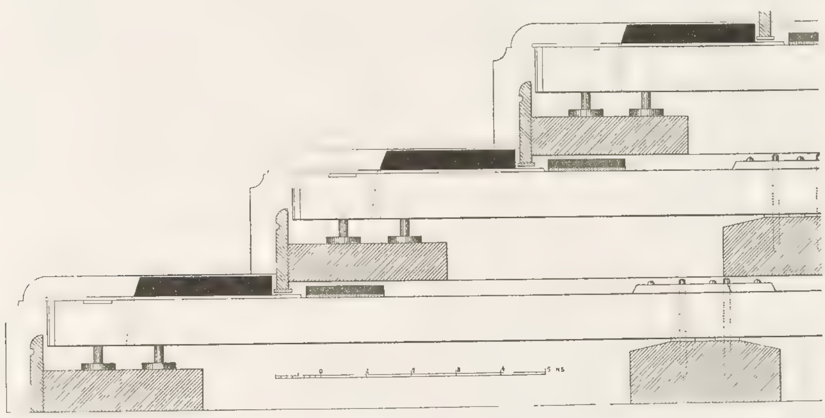


Fig. XCI.

the thumb-pistons between them, claviers having their nosings projecting to a moderate extent in advance of the front-beads will not prove objectionable; and about ¾ inch of distance can be gained in each clavier above the lowest one. In this treatment it will be desirable to make the overhanging fronts of the natural keys as thin as practicable and consistent with good appearance. The keys must not be notched over the front-beads in the manner shown in Fig. XC.; for it is desirable, if it is not necessary, to leave the front-beads perfectly clear at all times. The thumb pistons, or pneumatic or electric touches, should not be made to project far, if at all, from the face of the front-beads, otherwise they are liable to interfere with the performer's fingers while engaged on the clavier immediately below them.

It will be observed that in Fig. XCI. the keys are shown horizontal while up, or on touch, and in this respect differ from the keys shown in the other illustrations. This horizontal position has been advocated by one writer on the Organ, and

illustrated by another; yet we have no hesitation in pronouncing it objectionable from every point of view. The proper position of the keys, when they are on touch, is $3/16$ inch above the horizontal line at their playing ends; and when pressed down their position will be $3/16$ inch below the horizontal line. This adjustment will secure an agreeable motion under the finger. We have illustrated the horizontal position merely to show the objectionable adjustment sometimes adopted by those who do not attentively study the refinements of organ construction.

The front-bead which extends between the cheeks of the key-frame immediately behind the sharp keys of the highest or upper clavier may be treated in any manner called for by the general design of the key-case or console. As a thin and narrow slip it may be dispensed with altogether, the woodwork of the book-desk or the key-case being carried down to take its place. A rail connecting the cheeks, either in a plain or ornamental manner, may be used with a good effect, imparting an appearance of solidity to the fittings of the claviers. When the latter treatment is adopted, the rail may also be utilized as the thumper for the keys immediately below it, its under surface being covered with colored felt, the front edge of which will be seen. The under edges of all the cross-beads which have keys below them should have folded strips of bushing-cloth, or strips of colored felt, glued and tacked to them. These impart a neat and finished appearance to the claviers, and prevent much dust from entering the key-case or console. They are indicated in the illustrations.

As projecting or overhanging claviers are now almost universally used in good work by English and American organ builders, and should invariably be adopted for groups of three, four, or five claviers, a few remarks on their different treatments may be added to those already made. The only portion of the clavier which demands consideration is that known as the nosing. This portion may assume a variety of forms, according to the extent of the projection given to the keys, the materials employed in its finish, and the taste of the organ builder. The projecting treatment is frequently confined to the upper clavier or claviers of a series, the bottom clavier being finished square like that of a pianoforte. In the case of two claviers, this square treatment is quite satisfactory; but in groups of three claviers, the bottom clavier should be made to project beyond its front-bead and the front edge of the key-bench; which latter should be rounded or splayed downward so as not to obstruct the performer's view of the mechanical appliances usually placed above the pedal clavier. In groups of four or five claviers, this treatment of the lowest clavier and the key-bench is imperative when a satisfactory result is aimed at; its advantages have not, however, been generally realized by organ builders. In the Roosevelt standard claviers the same amount of projection is given to each row. This treatment is to be commended on account of appearance and utility. There is no reason why it should not be adopted in all cases where two or more claviers are introduced.

The nosings of projecting or overhanging claviers may be divided into two classes; namely, those which are entirely, and those which are only partly, in advance of the front-bead. In the former treatment, the keys are notched so as to allow the front-bead to enter them; while in the latter treatment, the keys are partly cut

away so as to display the front-bead entirely. To a great extent, and in all ordinary cases, it is a matter of taste which treatment is adopted. Expense is, however, a matter which few organ builders put aside as unworthy of consideration. The desire to save money is too often allowed to exert its pernicious influence, showing itself even in so prominent and obvious a thing as the manual clavier.

In the accompanying illustration, Fig. XCII., are given eight different forms of nosings, four of each of the classes above mentioned. These forms may be briefly described. The first form, at A, is highly suitable when a moderate pro-

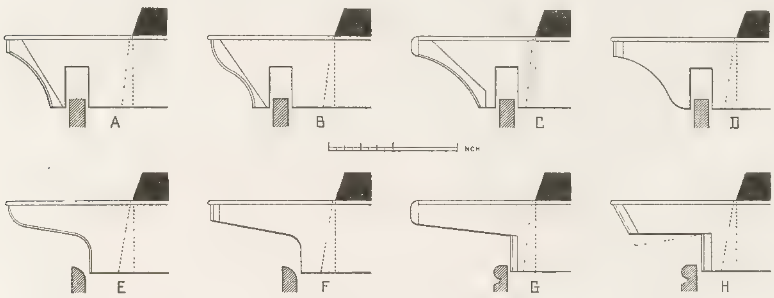


Fig. XCII.

jection, about 1 inch, is desired. The cavetto has a pleasing and light appearance, while it has no tendency, even in claviers that are close together, to interfere with the free motions of the fingers on the clavier immediately below. This nosing may be veneered with thin ivory, celluloid, ebony, rosewood, or satinwood, according to the character of the key-case and the analogous or contrasting effect aimed at. The second form, at B, is also for a nosing of moderate projection. The ogee contour, while it is perfectly suitable and convenient, is somewhat heavy in appearance in a row of keys, and is by no means so crisp and elegant as the cavetto form. The ogee may be veneered with any of the materials above mentioned, but preferably with ivory or white celluloid. The third form, at C, is for a nosing of considerable projection, the large cavetto being adopted to prevent interference with the fingers engaged on the clavier below. The chief peculiarity of this nosing lies in the application of a rounded end of solid ivory, covering the edge of the ivory plating, and extending from its upper surface to the commencement of the cavetto. This imparts a solid appearance to the keys; and increases the comfort while performing on two adjacent claviers with one hand, or while making rapid changes from one clavier to another. The cavetto should be veneered with ivory or white celluloid, so as to carry out the appearance of solidity already alluded to. It is almost unnecessary to remark that perfect workmanship is essential in a nosing of this character. The fourth form, at D, is also for a nosing of considerable projection. It is a suggestion for a most convenient and inex-

pensive treatment. The extreme end, immediately under the ivory plating, may be covered with ivory, celluloid, or ebony, while in every case the long ogee may be painted with black enamel color. As this under surface is rarely touched, and is never subjected to any wear, the enamel paint will last in perfect order for many years. Let the ivory plating be thick and of the best quality, and there need be no objection, on practical grounds, to the inexpensive treatment below. Of course, there is no reason why the long ogee should not be veneered instead of being enameled: it is simply a matter of expense. The fifth form, at E, which represents the second class of nosing, or that which partly passes down behind the displayed front-bead, has a very light and neat appearance, and is perfectly satisfactory from a practical point of view. The ogee may be veneered with celluloid, or finished with black enamel. The sixth form, at F, is suitable for a nosing of greater projection than the preceding one. Its extreme square end should be veneered with ivory, while all the remainder may be covered with black enamel. Ebony veneer may be used instead of ivory for the extreme end, if preferred. In either treatment, the effect of the clavier will be satisfactory. The seventh form, at G, is suitable for claviers having the maximum amount of projection. The extreme end is finished with a rounded piece of solid ivory, in the manner already described for the nosing represented at C. The back face, behind the front-bead, should be veneered with ivory, as indicated, while the soffit of the projecting portion may be veneered with celluloid or simply covered with white or black enamel. The eighth form, shown at H, is simply another method of finishing a nosing of similar proportions to the preceding one. It can be finished either with ivory or ebony veneer and white or black enamel. Should a deeper front be desired than is shown in this last form, the keys may be cut underneath in the manner indicated by the dotted lines.

It is not necessary to pass any special remarks on the forms of nosings for claviers which have no front-beads, and which have their bed-rails exposed, as in the case of those of the Organ in the Cathedral of Derry, already alluded to. It is quite obvious that all the forms shown at E, F, G, and H are entirely independent of the front-beads; their overhanging portions only requiring to be somewhat reduced to make them perfectly suitable.

In concluding our remarks on the front or playing portions of the manual claviers, we may say a few words respecting the old and exceptional modes of plating and combing the natural and sharp keys. It was quite a common practice in old times to plate the natural keys with ebony or some very dark colored wood, and to form the combs of ivory—the reverse of the almost universal modern custom. We say almost universal, because there have been several instances in modern times in which dark materials have been used for the natural and light colored materials for the sharp keys. The best materials to use, both on account of appearance and durability, are ebony and solid ivory. Stained ivory has been contemplated for the plating of the natural keys, but as no staining would be durable thereon it cannot be recommended. With ebony plating, combs of carefully selected boxwood have been used, producing a soft and harmonious effect. The combs can be made somewhat ornamental, when the plating is of ebony, by being built up of two side

pieces of ivory and a center layer of some very choice and richly colored wood. With the plating of ivory, the sharp keys have been made, as already mentioned, of two side pieces of ebony and center layer of ivory. All such treatments have been dictated by fancy or a desire to produce something out of the common; for from a practical point of view, and indeed from an artistic one also, nothing can surpass the simple application of ivory and ebony, as commonly seen in modern keyboard instruments.

Although, with the desire to save money, attempts have been made to find a satisfactory substitute for ivory, they have so far failed. The imitation of ivory in the form of celluloid should never be employed for the plating of organ claviers, while it may be used for veneering their nosings where they are not touched by the fingers in playing.

In the present Chapter we have practically confined our remarks to details connected with the front or playing portions of the manual claviers. For matters relating to the treatment of the back ends or tails of the manual keys, we must refer the reader to the Chapters devoted to the Manual Couplers and the different kinds of Manual Actions.

CHAPTER XX.

THE MANUAL COUPLERS.

—MECHANICAL—

THE system of mechanical coupling which obtains in the modern Organ deserves the careful consideration of the student of scientific and artistic organ-building; chiefly because one does not find the several couplers invariably introduced with due regard to the laws which govern the production of perfect musical sounds. That the couplers are valuable, when properly applied, there can be no question: but there is also no question that they are liable to be abused, to the disadvantage of the tonal balance of the instruments in which they are inserted. After many years of observation we have come to the conclusion that many couplers lead, under the hands of the average organist, to the production of noise rather than perfect tone. But in this he is not altogether to blame, for in too many modern instruments, built under the art-crushing competitive system, certain couplers are inserted in the attempt to cover obvious deficiencies in tonal appointment. Under such circumstances, they succeed in increasing the volume of sound, on the one hand, and in upsetting the proper balance of tone, on the other. It may be safely said that in an Organ whose pedal and manual divisions are properly appointed very few couplers are absolutely necessary; and that those which are introduced should be used with caution and judgment. The modern craze for numerous mechanical appliances and accessories has been a potent factor in the multiplication of the couplers; while the facilities afforded by pneumatic and electric actions have further encouraged their lavish introduction. While we have no intention of preaching a crusade against the use of the couplers, we desire to warn the organ builder of to-day against their injudicious insertion in artistic organ construction. As little temptation as possible should be given to the inexperienced organist to pile up heterogeneous sounds; and there are certain couplers which give him facilities for so doing, when in combination with imperfectly balanced

tonal appointments. The true musician and accomplished organist will always make a guarded and judicious use of the couplers; and in large and properly appointed instruments he will in all probability seldom resort to them, except for the production of full effects, or loud combinations of special tonal character.

Of the three classes of couplers, that known as the unison is the most important, and, indeed, the only one that is imperatively called for in any properly appointed Organ. This is properly a manual coupler; for the ordinary pedal coupler, which connects a division whose unison pitch is 8 feet to a division whose unison pitch is 16 feet, is strictly an octave coupler. The unison coupler can be attached to any manual clavier, and act on any other manual clavier. Accordingly we have the following: The Choir to Great Unison Coupler; Swell to Great Unison Coupler; and Solo to Great Unison Coupler—all of which belong to the Great Organ system. The Swell to Choir Unison Coupler; Solo to Choir Unison Coupler; and Echo to Choir Unison Coupler—belonging to the Choir Organ system. The Great to Swell Unison Coupler; the Choir to Swell Unison Coupler; the Solo to Swell Unison Coupler; and the Echo to Swell Unison Coupler—belonging to the Swell Organ system. The Great to Solo Unison Coupler; Choir to Solo Unison Coupler; Swell to Solo Unison Coupler; and Echo to Solo Unison Coupler—all of which belong to the Solo Organ system.

Now, while it is quite possible to introduce all the unison couplers, above enumerated, in an Organ comprising five manual divisions commanded by five claviers, it is not likely that even in a Concert-room Organ of the first magnitude would all of them be deemed necessary. In artistic organ construction, the selection and introduction of the unison couplers depend largely on the tonal appointment of the different divisions of the instrument under consideration. Large and well appointed divisions, in which the families of the more important stops are properly grouped, require comparatively little aid from unison couplers: but even in the best appointed instruments there will be found remarkable and beautiful tonal effects and combinations which could never have been produced in the absence of certain couplers. To anticipate these combinations, and secure the greatest variety of tonal effects, through the introduction of the proper couplers, and no more, careful study and considerable experience are required on the part of the organ builder or designer. This problem is usually solved, after a fashion, by the introduction of a superabundance of couplers, which is unfortunately attended by a complexity that is most undesirable. There is neither skill nor foresight in blindly multiplying such mechanical accessories and trusting to their being found useful. The true artist, in scheming an Organ, carefully considers its tonal appointment throughout every division; and only introduces such couplers as he knows will prove valuable in tone-creation, and which will render the production of desirable tonal combinations and effects easy to the performer, without confusing him by unnecessary complexity.

The true value of the unison couplers can only be fully realized in Organs in which all the manual divisions are rendered expressive, by having a portion or the whole of their speaking stops inclosed in swell-boxes. When two expressive divisions are coupled, and different qualities of tone are provided in each,—say, by a

combination of flute-toned stops in one and string-toned or reed-toned stops in the other,—most striking effects and subtile *nuances* are capable of being produced by a skilful performer, who, confining his fingers to the coupling clavier, imparts an expressive *crescendo* or *diminuendo* to either division at pleasure. The mysterious blending, diminishing, and swelling of the different qualities of tone, as either swell is operated are fascinating and beautiful in the extreme. In this matter we speak from long experience.

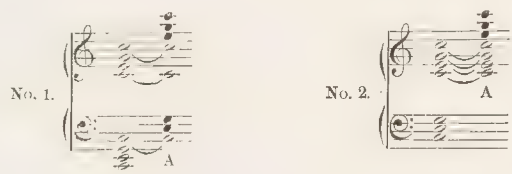
The octave couplers form the second class of the manual couplers; and deserve very careful consideration, for in numerous cases they have been introduced with questionable judgment, as we shall endeavor to show. This coupler, when properly applied, connects the octave of one manual clavier or division to the unison of another manual clavier or division. It has been, and still is, frequently designated the super-octave coupler; but this term is obviously incorrect, for it implies that the coupler connects one manual to another in the second octave above. When one speaks of a stop as a SUPER-OCTAVE, one does not allude to a stop only one octave higher in pitch than the unison, but to a stop two octaves higher in pitch. We are not aware of a true super-octave coupler ever having been introduced between two manual divisions of an Organ; and it certainly would not be desirable to introduce it.

While the octave coupler is by no means as valuable as the unison coupler, it is useful in Organs of moderate or small dimensions, as a means of increasing the variety of their tonal effects, which the limited number of their speaking stops and manual divisions would, without the aid of such a coupler, be incapable of producing. As an Organ is increased in size, and as each of its manual divisions becomes more complete and satisfactory in its tonal structure and appointment, the octave coupler becomes less necessary, and its use less frequently resorted to by the accomplished performer. At all times the octave coupler has to be judiciously used; for by its unskilful use the balance of otherwise beautiful combinations of tone may be seriously impaired. It is true that it requires a highly cultivated musical sense to realize the objectionable element too often introduced by the octave coupler; but it is none the less a fact that many perfectly satisfactory combinations of tone are completely upset by the unscientific addition of octave voices. This leads us to remark that, both from a scientific and practical point of view, it is unadvisable to introduce the octave coupler acting on its own clavier, because, in this case, it is impossible to obtain the octave of a different tonal character from that of the unison. It is radically wrong, from a scientific point of view, to have the octave, which creates or corroborates the first upper partial tone, as powerful as the prime or unison tone. This fact is, or should be, recognized in scheming the tonal structure of properly appointed Organs.

It must be clearly understood that with the octave coupler acting on its own manual very irregular and unsatisfactory tonal effects are produced—effects which vary continuously as the fingers of the performer wander over different portions of the clavier. It is certain that in playing chords simultaneously with both hands, having a clear octave between them, an effect will be produced widely different, as regards the operation of the coupler, from that which accompanies the playing of

similarly constituted chords close together. In the former case, the coupler is able to add certain notes to both the chords, producing an effect approximating that obtained by the addition of an octave stop: while in the latter case, a very different result is produced, because, in all probability, only certain of the higher notes of the chord, or portion of the chord, taken by the right hand will be duplicated in the octave; most, if not all, of the notes of the chord, or portion of the chord, taken by the left hand, duplicated by the coupler, falling on the notes already held down by the right hand, and, accordingly adding nothing to the middle of the resultant chord.

The accompanying two examples are given to clearly explain what has just been said. In the first example, the chords, or parts of the full chord, taken by the left and right hands, are an octave apart, permitting the octave coupler to introduce two clear notes between them. At A are indicated the notes introduced by



the coupler; the three tied notes belong to the original chord, while the five black notes are the only additions made to the chord. In the second example, both parts of the full chord lie closely together; and here, again, the tied notes show the imperfect character of the octave coupler which acts on its own manual, while the black notes show the objectionable element it adds to the otherwise satisfactory unison chord. Under such circumstances, it is obvious that the above coupler can never take the place of an independent octave voice in tonal appointment.

The above objections do not obtain when the coupler acts between two independent manual divisions; simply because it then brings on the octave voice on every unison note played; and it also enables the performer to adapt the octave tones to the unison ones. This control also enables the player to produce, within certain limits, a variety of tonal effects, by having the octave voices different in quality from the unison. Different tone colorings—slight it is true—may be obtained by the introduction of octave voices of different strengths of tone as well as of different qualities.

Let it be borne in mind by all interested in the construction or acquisition of Organs, that octave couplers, however applied, are rather luxuries than necessities; and above all let them see that the octave couplers are not introduced to cover positive shortcomings in the tonal appointments. In testing the tonal capabilities of an Organ, no resort should be made to the octave couplers, for if they are not satisfactory without them they will never be satisfactory with them.

In introducing the octave coupler, the organ expert should carefully consider the tonal appointments of the divisions (when more than two manual divisions are

present) between which it would be most suitably placed. In an Organ of three manual divisions, the most desirable octave coupler is the Swell to Great, not only because, as a general rule, the stops in the Swell Organ will be the most suitable ones to be coupled in the octave to the Great Organ stops, but because the flexible character of the Swell Organ favors the adjustment of the tones of its voices to the prime tones of the dominating voices of the Great Organ. When the Choir Organ is expressive, it may, with safety, be coupled in the octave to either the Great or Swell Organs. No rules of general application can, however, be given, for all depends upon the tonal appointments of the several divisions, and the nature of the Organ, and the uses to which it is to be put. The golden rule with reference to the couplers of all classes is: Introduce no more than are absolutely necessary or desirable; and do not depend upon them for the production of tone-color or tonal effects that should be amply provided for in the stop appointment of the Organ. As we have already said, couplers are luxuries, not necessities, in a properly appointed instrument.

The third form of manual coupler is that commonly designated the sub-octave coupler, but which might conveniently, and perhaps more correctly, be called simply the sub coupler. This coupler, when properly applied, connects one manual clavier or division to another manual clavier or division in the octave immediately below. It is chiefly resorted to to obtain a 16 ft. tone upon a manual whose division does not contain a stop of 16 ft. pitch; or to obtain a 16 ft. tone of a different strength and quality in special combinations. This coupler, however, is so far imperfect that it ceases to operate below tenor C, just as the octave coupler, under ordinary conditions, ceases to act above the note that is an octave below the top note of the clavier played upon. This shortcoming in the sub coupler clearly shows that it should never be introduced as a substitute for a speaking stop of 16 ft. pitch, the grave tones of which are so valuable in the bass octave. The most suitable position for the sub coupler is between an unexpressive and an expressive division; for instance, when it connects the Swell to the Great Organ. In such a case it is possible to obtain a considerable variety of double tones from the unison voices of the Swell Organ, under the modifying influence of the swell shutters, controlled by a balanced expression-lever. In an Organ of moderate size it is usual to have a soft stop of 16 ft. pitch, such as a small-scaled BOURDON, or a LIEBLICHGEDECKT, in the Swell division: and when such is the case, the Swell to Great Sub Coupler loses much of its value, for the unison coupler brings the double tone on the Great throughout its entire compass. By using the sub coupler, with the double drawn in the Swell Organ, a 32 ft. tone is added to the Great down to tenor C, producing some valuable tonal effects when judiciously employed. Like the octave coupler, the sub coupler is a somewhat dangerous accessory in the hands of the unskilful or inexperienced performer, who is very apt to confuse two things; namely, volume of sound with proper balance or refinement of tone.

As the true unison, or 8 ft., pitch of the manual divisions should be carefully guarded, it is never really desirable to introduce a sub coupler acting on its own division. In a properly and scientifically appointed Organ the sub coupler will

be rarely used; that is, if it is used with judgment and taste, and in accordance with the laws which govern musical sounds. Its introduction between other manual divisions of the Organ than those above mentioned should depend upon the tonal appointments of the different divisions; and to some extent upon the special aims of the expert who designs the instrument, notably if it is designed for his own particular use.

In small Organs of two manual divisions,—Great and Swell,—in neither of which is a stop of 16 ft. pitch, the Swell to Great Sub Coupler is unquestionably of great value; for without it it would be impossible to obtain a double voice so valuable in Great Organ combinations. In Chamber Organs of such limited proportions the sub coupler, acting between its divisions, should always be introduced. But it must be remembered that under such circumstances the coupler is a very poor substitute for an independent soft voice of 16 feet pitch.

THE UNISON COUPLERS.

In this section of the present Chapter we shall confine ourselves to the description of the mechanical couplers immediately connected with the manual claviers, and properly placed directly between them, such being of necessity unison couplers. These couplers are of two classes; namely, those which connect a higher clavier to a lower one; and those which connect a lower clavier to a higher one. The former couplers have a pushing, while the latter couplers have a pulling action.

A properly constructed coupler must possess two properties; it must be adjustable, and it must be so formed as to be easily brought into action while the keys are depressed. Some of the earlier devised couplers did not meet these demands, and have accordingly been abandoned. Of the couplers which connect a higher clavier to a lower one, the best are those known as the drumstick coupler and the sticker coupler. In the former, the regulation is provided for in the key bodies; while in the latter, the stickers carry their own regulating appliances. Both these couplers have distinct advantages; and both are brought into action by a simple sliding motion.

The drumstick coupler derives its name from its contour, which somewhat resembles that of the "stick" of a bass drum. It consists of a narrow shank terminating in a large circular part, the edge of which is covered with a layer of cloth and leather, to prevent noise when in contact with the tails of the keys. The buffing of cloth and leather has sometimes been applied to the key tails, or inclined blocks attached thereto, instead of to the coupler heads, but this method is not to be recommended. There is, of course, a separate drumstick coupler for each key in the compass of the manuals affected: and the entire series is held in proper position and operated by a horizontal stock of wood, to which the couplers are hinged or pivoted in notches or channels cut for their reception. The form of the couplers and the manner in which they are mounted in the stock are shown in the accompanying illustration, Fig. XCIII. The form of the coupler is given at A; while the stock is given, in transverse section, at B, showing the manner in which the shank of the coupler extends into its notch, and is hinged on a wire running along the

notched face of the stock, and secured to the same by small wire staples. The couplers are bushed with cloth so as to move easily and noiselessly on the wire. The buffing, with its layers of thin cloth and leather, is indicated round the head of the coupler at C. A view of three couplers, as seen from above, is given at D, showing the manner in which they are held parallel, and in correct position with respect to the manual keys, by the deep notches in the stock B. The drumstick couplers are formed from a piece or pieces of straight-grained bay-wood, or some other light hardwood, cut from the end of a plank of the thickness required for their circular heads. For a complete set of sixty-one couplers, a piece of bay-wood 22 inches long is required, its width—lengthwise of the grain—being sufficient for the length of the couplers. The piece is worked throughout its entire length to the contour of the couplers, carefully finished, and varnished with shellac varnish

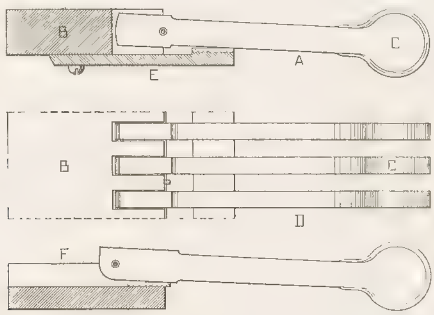


Fig. XCIII.

save where the buffing is to be applied. When this is done, the couplers are cut off, one after the other, with a fine band or circular saw; and then planed on their sides to the exact thickness required, usually $\frac{7}{32}$ inch. Their shanks are drilled and bushed with cloth in the usual manner. Strips of thin red cloth are glued round the edge of their circular ends; and subsequently strips of sheepskin are glued over the cloth, with the dressed side outward. The projecting edges of the buffing are cut, with a sharp knife, level with the sides of the couplers, completing their formation.

When the manual clavier that lies above the coupler is played, the tails of its keys move upward and away from the coupler; accordingly, it is only necessary that when the coupler is out of action it should drop a very slight distance away from the key tails; at the same time it is desirable that the coupler should not drop upon the keys underneath it, so as to always move along with them and probably cause noise by dancing on them in rapid or *staccato* playing. Under these circumstances, it is desirable to provide means of supporting the coupler in proper position when it is out of action. This may be done by simply screwing a thin strip of wood along the under side of the stock, and gluing and tacking a

narrow strip of thin felt along its edge, on which the coupler shanks can rest, as indicated at E. Or the shanks may be pivoted in grooves cut in the upper surface of the stock, as shown at F, when the bottoms of the grooves serve as supports for the shanks when the coupler is out of action. The coupler is put in and out of action by being moved forward and backward between the lower and upper claviers, as is fully shown farther on.

As the drumstick coupler admits of no alteration in vertical dimensions for the purpose of minute adjustment between the two claviers, such adjustment has to be provided in the tails of the keys. And as the lower keys must have room to move without touching the coupler, when it is out of action, they have to be blocked up just sufficiently to contract the space between them and the under surface of the upper keys to receive the buffed heads of the coupler, in close contact, when it is moved into action. The drumstick coupler is most suitable for claviers that are placed closely together, because with them it does not require to be made inconveniently large, and blocking of moderate dimensions is all that is necessary.

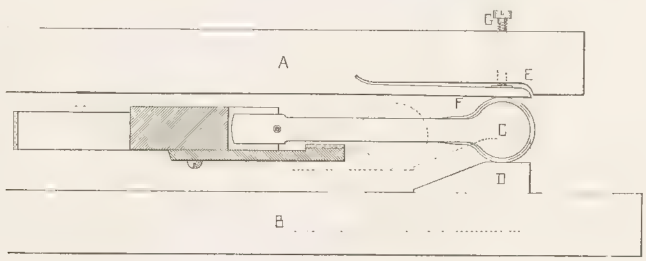


Fig. XCIV.

In Fig. XCIV. is shown the coupler, in action, between the tails of two keys. The upper key A is here coupled to the lower key B by means of the contact instituted by the circular head of the drumstick coupler C, which fits accurately between the upper surface of the block D and the under surface of the key A. The block D is firmly fixed to the lower key B, and should form part of the original construction of the same. Its upper surface must be very smooth and well black-leaded: it does not require to be leathered, as the coupler is buffed, as previously described. The method of fine adjustment shown is that called the "split-key adjustment." It consists of a fine saw cut made in the under side of the upper key, at E, of the form indicated. This permits the thin tongue of wood F to act as a spring, capable of being depressed by the flat-ended, brass adjusting screw G, which has a fine thread and no taper. To prevent the end of the screw indenting the soft wood of the tongue, a small piece of brass or spotted metal should be interposed between them, as indicated. By this simple arrangement, the most accurate adjustment of the coupling action is readily obtained by turning the screw G when the keys are in position. The dotted portions of the illustration

show the position of the coupler when out of action, and the position of the coupler block D when the lower key B is pressed down by the player's finger. In the positions indicated by the dotted lines, the coupler can be readily brought into action, its head C gliding up the inclined plane of the block and raising the tail of the upper key A. It is a matter of importance that the manual couplers, of all descriptions, should be readily brought into operation while the claviers are being played upon. The drumstick coupler is put into and drawn out of action by a forward and a backward motion of its stock, which slides in openings made in the cheeks of the key-frame; the ends of the stock being linked to the coupling mechanism, controlled by a draw-knob or foot-lever. To secure perfect smoothness of action, it is necessary to black-lead the buffing of the coupler, and the surfaces of the keys with which the buffing comes in contact. If the coupling mechanism is such that there is a possibility of the drumstick coupler gradually moving back and out of action, while the keys are being used, it will be advisable to form a slight segmental depression, either in the top of the block D, or in the under side of the tongue E, exactly where the circular head of the coupler rests while it is in action. As this will be done throughout the compass of the claviers, the coupler will be effectually prevented from slipping out of action. The shanks of the drumsticks must be so accurately fitted in the notches or grooves of the stock as to prevent their having any objectionable lateral play where they bear on the keys.

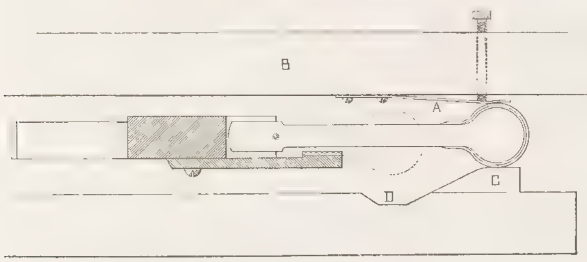


Fig. XCV.

The drumstick coupler can be conveniently fitted with another form of adjustment, which does away with the necessity of splitting the tails of the upper keys. This is shown in Fig. XCV. It consists of the hard brass spring A, screwed at one end to the under side of the upper key B, and pressed downward near its free end by the adjusting screw which passes through the tail of the key, as indicated. This spring fulfils the same office as the tongue cut from the substance of the key does, as described above; and in some respects it is to be preferred to the wooden tongue. To prevent the circular head of the coupler slipping back and rendering its operation imperfect, the end of the spring A may be bent slightly upward, just beyond the point where the adjusting screw bears upon it, as shown. As the spring adds somewhat to the depth of the upper key, adjoining the coupler, the

inclined block C will be made proportionately lower: and this may render it necessary, to keep the lower key free of the coupler when out of action, to make an indentation in the key, as shown at D, carrying the inclined plane into it. With this spring adjustment the drumstick coupler may be conveniently used with claviers placed wider apart than those contemplated in Figs. XCIV. and XCV. It will be only necessary to block the adjusting spring A down to the required distance where it is screwed to the key B, and to employ a longer adjusting screw. All the other parts may remain as shown in the illustrations, unless it is found desirable to further increase the depth of the inclined blocks, and avoid cutting into the lower key tails.

The spring adjustment, as shown in Fig. XCV., may be considered preferable to the split-key adjustment, as shown in Fig. XCIV., because it allows a larger range of adjustment without becoming in any way impaired. In the case of the wood tongue very little motion is possible; and there is always danger of its becoming set after it has been kept strained for a long time, and refusing to spring back when the adjusting screw is withdrawn. The only objection that can be advanced to the use of the spring regulator is its cost; but that is too small a matter to be considered by an artistic and painstaking organ builder.

There is another form of adjustment, suitable in connection with the drumstick coupler, known as the button regulator. When properly constructed this is perfectly satisfactory, although we do not consider it so good as the spring regulator. The button regulator is formed by firmly attaching a small circular piece of wood or thick sole leather to the lower end of a stout tapped-wire of phosphor bronze, which passes down through the tail of the upper key, in the same manner as the regulating screw in the above-described spring adjustment. The button, as the circular piece is termed, may be kept entirely below the under surface of the key; or it may be sunk in a circular hole, somewhat larger than the button, bored in the key, with its smooth face, when properly adjusted, not exceeding $\frac{1}{16}$ inch below the under surface of the key. When it is kept entirely below the key, a sloping block must be attached to the latter to conduct the head of the coupler on to the surface of the button; both block and button being well black-leaded. The sunk regulator is indicated at A in the accompanying illustration, Fig. XCVI.; a sloped block being necessary only on the lower key. The free button regulator is shown at B, which requires the sloped block C to guide the head of the coupler to its surface, as already said. The lower key has to be blocked and hollowed out in the manner indicated.

Not only is the drumstick coupler, when properly constructed and adjusted, perfectly satisfactory when in action, but it has the advantage over certain other couplers, placed between claviers, of being easily brought into action while the claviers are being played upon; that is, while a number of the lower keys are held down. Unison couplers which did not meet the above conditions were commonly introduced in English Organs built during the first half of the last century. Illustrations of these imperfect couplers appear in several treatises on organ-building; notably in that entitled "The Organ, its History and Construction." The most imperfect form is that called the "tumbler coupler." This consists of a strong

square or octagonal rod of hardwood, pivoted at each end so that it can be turned partly round by the coupler action. The rod is perforated opposite each key with a small oblong slot, measuring about $\frac{3}{8}$ by $\frac{1}{4}$ inch: and in each slot is inserted a small jack or sticker of hardwood, sliding easily, and well black-leaded. Its upper end is so shaped as to prevent its falling through the slot when the rod is turned to put the coupler out of action; and both its ends are rounded to enable it to slide easily into action without moving the keys. The jack is of sufficient length to exactly fit between the upper surface of the under key and the under surface of the upper one when in action, or in the vertical position. When the coupler is turned sufficiently to raise the lower ends of the jacks about $\frac{1}{2}$ inch above the lower keys it is put out of action. No minute adjustment was apparently provided for the tumbler coupler, although the split-key adjustment would have been

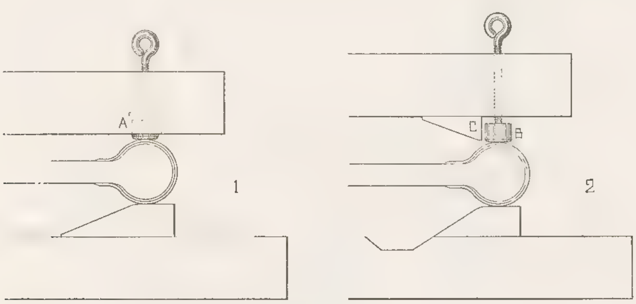


Fig. XCVI.

highly suitable. The coupler was essentially imperfect because it could not be thrown into action with ease and safety while the lower clavier was being played.

A somewhat improved form of jack coupler was subsequently introduced by Messrs. Kirtland and Jardine, of Manchester. This form consists of a square or oblong, slotted rod, which has a sliding motion parallel to the claviers. The jacks are very similar in general form to those used in the tumbler coupler, and move vertically in the slots of the rod. To enable this sliding coupler to move into action easily, the lower keys are slightly hollowed on their upper face, forming a series of inclined planes, up which the lower ends of the jacks glide. The upper keys are also hollowed, on their under side, and are furnished with adjustable buttons, carried on the ends of tapped wires, against which the heads of the jacks rest when the coupler is drawn. To prevent noise and undue friction the lower keys are buffed, and all working parts and surfaces are well black-leaded. This coupler, like the tumbler coupler, cannot be brought into action, while the lower clavier is being played, with any ease or certainty, especially if the touch of the upper clavier is heavy. Both the tumbler and the sliding jack couplers have long been abandoned by good builders, and deserve to be classed among the curiosities of organ-building. The obvious imperfections of these couplers led to the inven-

tion of the sticker couplers; several forms of which have been introduced by English and American organ builders.

The earliest practical form of the sticker coupler used in English Organs is the one shown in Fig. XCVII. The stickers A are of hardwood, about 3/8 inch by 1/4 inch in cross section, rounded at their upper ends, and furnished with tapped-wires at their lower ends, in the manner indicated. The tapped-wires pass through properly formed holes in the lower keys at B, where they are held in correct adjustment by the bearing buttons C; the under buttons D only being required to prevent the stickers remaining up through any cause. The stickers pass through oblong and oblique slots in the register E, which slides in openings cut in the cheeks of the key-frame, and is connected to the coupler action at its free ends. The upper keys are notched out so as to allow the coupler to move freely when

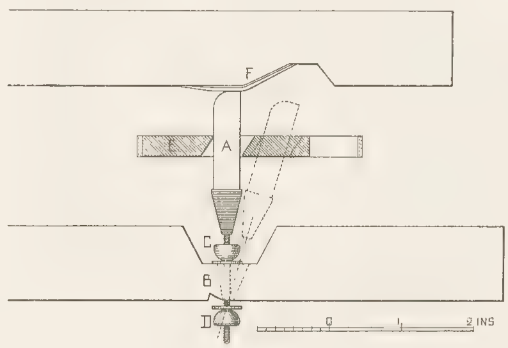


FIG. XCVII.

not in action, and to provide inclined planes for the stickers to glide upon when the coupler is brought into action while the lower keys are being played. The inclined planes F, and the under side of the keys where the stickers rest, are buffed with two thicknesses of strained sheepskin, or with a layer of bushing-cloth and a layer of leather, as indicated. The stickers, the slots in the register, and the surface of the buffing, are all well black-leaded. In the construction of the clavier to which this coupler is attached, the weight of the stickers has to be taken into account. Upwards of thirty years ago we tested the practical value of this simple form of sticker coupler in our own Chamber Organ, and found it satisfactory in all essentials: and we are not aware of anything better, in the shape of a sticker coupler, placed between the manual claviers, having been introduced in English Organs. We have not found this form of unison coupler, or, indeed, anything approaching it, illustrated in the works on organ-building hitherto published.

To find the unison sticker coupler in its highest development one must look to the works of certain American organ builders, in which one finds that careful attention to minute detail which is rarely met with in the works of European build-

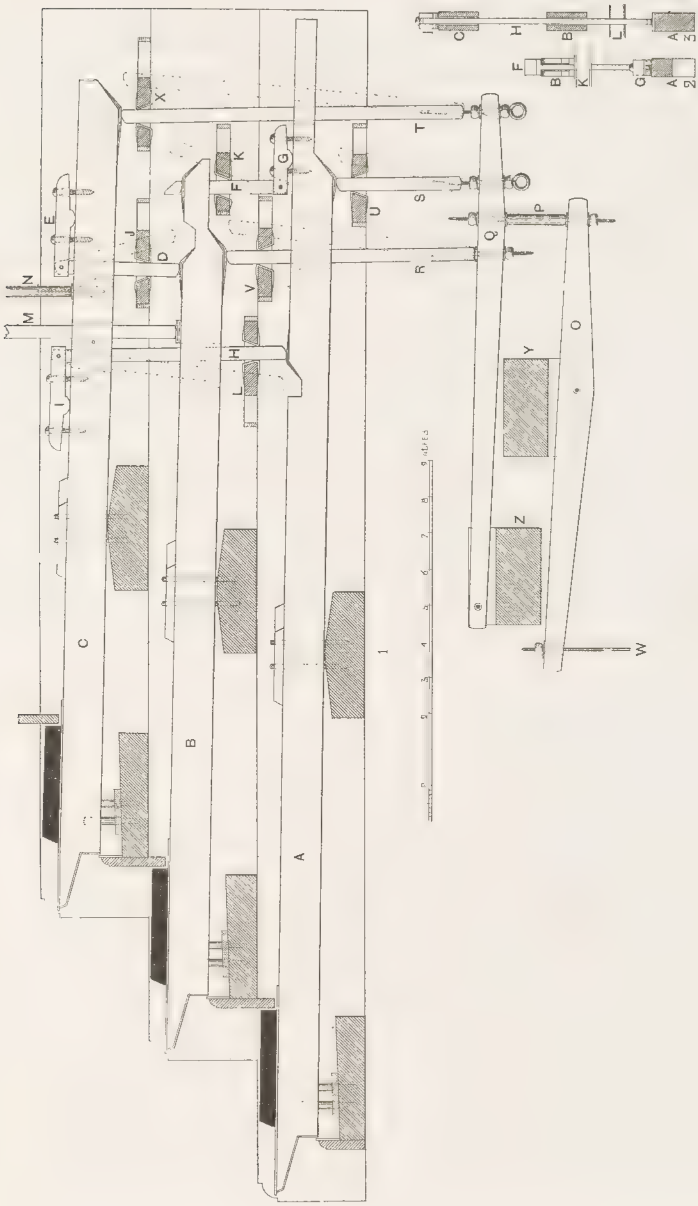


Fig. XCVIII.

ers. We select for illustration and description the standard arrangement of the manual claviers and unison couplers as adopted by the most celebrated American organ builders—the late Messrs. Roosevelt, of New York. This arrangement is shown in the accompanying illustration, Fig. XCVIII. It is extremely interesting on account of the highly ingenious manner in which the several couplers are disposed so as to be easily adjusted and to operate without interfering with the key action. It will be seen, on referring to the illustration, that there are six couplers in all, three manual unison couplers and three pedal couplers, each of which is furnished with ready means of accurate adjustment. We shall confine our remarks to the manual couplers in the present Chapter. The claviers are, respectively, the Choir, A; the Great, B; and the Swell, C; the usual, but in our opinion the undesirable, order, as pointed out in the Chapter on the Manual Claviers. Starting at the Great Organ clavier, the first coupler to be considered is the Swell to Great, shown at D. Its flat stickers pass first through the sliding register J, and thence through slots cut in the center of the Swell keys C, above which they are hinged to the rocking, adjusting bars E, in the manner indicated. The rocking bars are secured to the upper surface of the Swell keys by two screws each; and these screws, operating against each other, provide an easy and perfect adjustment of the coupler without necessitating the removal of any keys—a matter of considerable importance. Both the register and the surfaces of the Great keys on which the stickers glide and rest are well buffed and black-leaded. When the coupler is out of action its register is moved back, placing the stickers in the oblique position indicated by the dotted outline. The Swell to Choir Coupler is formed on precisely similar lines. Its stickers H pass through the sliding register L, then through slots in both the Great and Swell keys, until they reach the rocking, adjusting bars I. These bars are in all respects similar to those of the Swell to Great Coupler already described. The manner in which the stickers pass through the Great and Swell keys is shown in Diagram 3. When the coupler is out of action its register is moved forward, placing the ends of the stickers over the notches cut in the Choir keys, as indicated by the dotted outline. Both the Swell to Great and Swell to Choir Couplers are strictly sticker couplers, having the pushing motion belonging to sticker actions: but we have now to consider a coupler that has a pulling motion, and which might be designated a tracker coupler. This couples the Choir to the Great keys, and is shown at F. The connecting rods F are hinged to the rocking, adjusting bars G, which are secured by screws, in the manner already described, to the upper surface of the Choir keys A. The rods pass upward through the sliding register K, and enter into the forked tails of the Great keys B, in the manner shown in Diagram 2. The connecting rods F have enlarged heads which bed upon the buffing of the forked tails, as indicated in Diagram 2, and also in the large drawing. When the coupler is in the position shown, the Choir keys can be played without affecting the Great keys, the coupler rods moving easily and without friction in their forked tails; but when the Great keys are played the Choir keys are likewise moved. The dotted outline of the connecting rods shows their position when the register K is moved back, and the coupler is out of action. This coupler, like all the others shown in the drawing,

can be brought into action while the claviers are being performed upon. The several couplers are adjusted to the greatest nicety, so as to move the keys to precisely the extent required, all undesirable action or straining being carefully avoided. Indeed, the workmanship of these standard claviers is of the most accurate and painstaking description, down to the most minute detail. The three manual to pedal couplers R, S, T, are described elsewhere. The Great Organ action is connected with the keys by the flat stickers M, which rest on the upper surface of the Great keys B, and pass through the slots in the Swell keys C, as indicated by dotted lines. The round stickers N are connected with the Swell Organ action. The Choir Organ action is connected directly with the elongated tails of the Choir keys A in any convenient manner. The workmanship in the Roosevelt claviers is invariably of the most beautiful description; and complicated as their system of unison couplers, as above described, may appear, every part works with the utmost ease and regularity. All the adjustable couplers were made by hands specially trained for such small work, aided by special machinery; and, accordingly, they had only to be furnished with their sliding registers, and screwed to the keys by the organ builder. American organ builders of the first rank exercise great ingenuity, skill, and care in all such mechanical details; and in this direction probably surpass the builders of all other countries.

In the forms and arrangements of the manual unison couplers, as directly attached to the claviers, a considerable difference obtains in the works of different builders; but as the same principles of construction and action are present in all good examples, it is unnecessary to go beyond what has been already illustrated and described in this direction.

THE KEY ACTION UNISON, OCTAVE, AND SUB COUPLERS.

Notwithstanding the fact that considerable ingenuity and mechanical skill have been expended by distinguished organ builders on the design and arrangement of the unison couplers directly connected with the manual claviers, as shown in the preceding section, there seems to be a disposition on the part of the builders of to-day to discontinue their introduction. That this is altogether wise is open to question; for it is quite certain that the couplers placed between the claviers have several advantages over those constructed in the key action that should not be overlooked. They are certainly well adapted to the requirements of the detached console when the tracker action is used. The advantages claimed for the key action couplers are that, in the first place, they do not crowd the claviers with undesirable parts, which generally render the removal of the keys and their exact regulation somewhat troublesome; and that, in the second place, they are absolutely necessary, in connection with tracker actions, for the convenient construction of the octave and sub couplers between different divisions of the Organ.

It must be noted that in the ordinary, unaided tracker actions the couplers now under consideration, in common with those directly connected with the claviers as previously described, are objectionable inasmuch as they practically double the weight of the touch of the claviers from which they act. For instance, the

Swell to Great Coupler throws the weight of the Swell Organ touch on to that of the Great Organ; while the Swell Organ touch is in itself unaffected when the Swell clavier is played upon. In small Organs of two manuals, having light tracker actions, this additional weight on the Great Organ keys, when the Swell to Great Unison Coupler is drawn, does not cause serious inconvenience to the performer who is accustomed to it. In Chamber Organs, voiced on light wind, and furnished with delicate, perfectly balanced, and carefully regulated tracker actions —the best of all actions for such instruments—both the Swell to Great Unison and Octave Couplers may be drawn without seriously impairing the Great Organ touch.*

In large Organs, having tracker actions, the inconvenience caused by the several couplers acting from the Great Organ clavier was found to be so great that it became a common practice, as in numerous English and French instruments, to introduce the pneumatic lever action in the Great Organ, and causing it to operate all the manual couplers. We have before us, as we write, the drawings of the fine Organ in the Church of Saint-Martin, at Amiens, constructed by MM. J. & E. Abbey, of Versailles, in which this arrangement is admirably carried out. The introduction of the pneumatic lever, of course, removes all inconvenience caused by the multiplication of couplers acting from the Great clavier; for however many couplers may be drawn, the touch, which is adjusted for the pneumatic levers, remains constant.

In the couplers now under consideration the connections are accomplished by means of simple arrangements of backfalls, or of backfalls and squares in combination, operating from one set of trackers or pull-downs on another set of trackers or pull-downs; the backfalls or squares being put in and out of action by the movement of the beams on which they are pivoted or carried. The manner in which the couplers are constructed and disposed depends entirely upon the arrangement of the complete key action, and the relative positions of the trackers or pull-downs to be coupled. Such being the case, it is only possible here to give the general principles upon which such couplers are formed. The direction in which the action from each clavier is carried depends mainly upon the locality of the corresponding wind-chest; and, accordingly, a special system for the efficient working of the couplers has to be schemed for every differently planned Organ. The couplers may operate either on horizontal and parallel trackers or on vertical trackers or pull-downs, as the internal arrangement of the Organ may dictate. In both cases it is desirable to keep the couplers as close to the claviers as practicable, so that there may be no perceptible lost action, and so that the coupled keys may readily respond to the movements of the couplers.

The simplest form of coupler, suitable for a small Organ of two manuals, the wind-chests of which are placed parallel and close together, consists of two sets of backfalls, so arranged as to communicate the motion of the pull-downs of one wind-chest to the pull-downs of the other wind-chest, at the will of the perform-

* In our own Chamber Organ, voiced on 2⅜ inch wind, and having an extremely delicate tracker action, perfectly regulated, we could draw the three couplers—Choir to Great Unison, Sub, and Octave Couplers—without overweighting the touch of the Great Organ clavier.

er. This arrangement is shown in the accompanying diagram, Fig. XCIX., in one of its forms. Supposing that the coupler is Swell to Great; one of the pull-downs of the Great Organ wind-chest is indicated at A, while one of the Swell Organ pull-downs is indicated at B. These are coupled by means of the two backfalls C and D, which are carried by the beams E and F, in the usual manner. The portions of the Great and Swell wind-chests through which the pull-downs from the pallets pass are shown at G and H. The pull-downs A and B are supposed to be connected at their lower ends with roller-board or fan-frame actions. The beam E is a fixture, while the other beam F is capable of being raised and lowered by means of some simple mechanical device commanded by the coupler draw-knob adjoining the claviers, and, probably, also by a foot-lever. When the coupler is "drawn," the beam F is lowered, bringing the inner, rounded, and leather-covered ends of the backfalls C and D into close contact, as shown in the

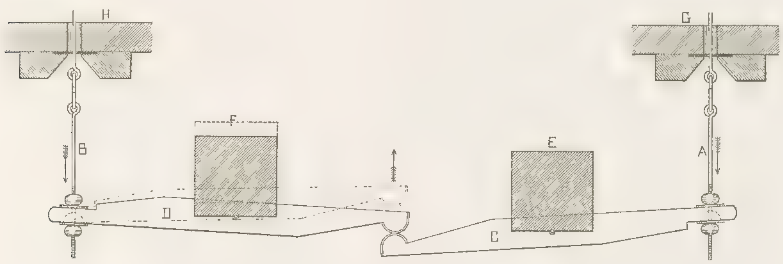


Fig. XCIX.

diagram. Now, when the wire A is pulled down by the key action, the motion is conveyed through the rocking backfalls to the wire B, which is pulled down by the backfall D. When the coupler draw-knob is pushed in by the performer, or the foot lever is released or its action reversed, the beam F is raised to the position indicated by the dotted lines, and the inner end of the backfall D is lifted sufficiently far from the corresponding end of the Great Organ backfall C to prevent any communication of motion. The Great Organ coupling backfalls can now move along with the key action without in any way affecting the Swell Organ action. To disconnect the coupler backfalls it is only necessary to raise the beam F about a quarter of an inch.

The arrangement above described is very suitable for the Swell to Great Octave and Sub Couplers; indeed, it should only be used for them, the Swell to Great Unison Coupler being more conveniently placed, in the sticker or drumstick form, between the claviers, in the manner previously described. In the construction of the octave and sub couplers it is only necessary to dispose the two sets of backfalls obliquely so as to span the octaves. When both the octave and sub couplers are introduced, it is, of course, necessary to have two double sets of backfalls, placed one over the other and as close together as practicable. When the pipes are planted semitonally throughout the compass of the instrument,

backfalls only will be required for the octave and sub couplers; but this regular semitonal arrangement is very rarely used in English and American Organs. The usual arrangement, in small instruments, is to plant the bass and tenor pipes, say from CC to G—twenty notes—alternately on the left and right of the remaining pipes. This disposition places the CC, DD, EE, FF♯, GG♯, AA♯, C, D, E, and F♯ pipes on the left end of the wind-chests; and the CC♯, DD♯, FF, GG, AA, BB, C♯, D♯, F, and G pipes on the right end. This arrangement renders it necessary to introduce a roller-board for six notes, in both the octave and sub couplers, in conjunction with the backfalls. In the octave coupler the roller-board is required for the notes AA, BB, C♯, D♯, F, and G, of the Great Organ, coupling them with the corresponding octave notes which occupy the left portion of the Swell wind-chest. It will be found, in laying down the lines for the octave coupler according to the above arrangement, that five of the backfalls connected with the roller-board cross the backfalls of the highest five notes in the same coupler: this necessitates the pivoting of the roller-board backfalls on the upper side of the backfall beams; while all the others are pivoted on the under side, as shown in Fig. XCIX. In the sub coupler the roller-board is required for the notes A, B, $c\sharp^1$, $d\sharp^1$, f^1, and g^1, of the Great Organ, coupling them with the corresponding notes of the lower octave which occupy the right hand portion of the Swell Organ wind-chest. There are no crossing backfalls in this coupler.

A simple and efficient unison coupler, connecting a horizontal Swell Organ action to a vertical Great one, in the immediate neighborhood of the claviers, is shown in Fig. C. A is the tail of a Great key from which rises the flat sticker B, passing through a mortise cut in the tail of the Swell key C, or between notches cut in the sides of the keys, as indicated in the Plan. In this latter case, the tails of the Swell keys have to be skewed equal to one half the key width, so as to allow the stickers B to stand on the center of the Great keys below. The horizontal Swell action is connected to the key C by means of the T-square D, carried in the stationary beam E. It will be observed that the rounded end of the T-square is inserted in the forked end of the Swell key: this is done so that the key shall always follow the motion of the coupler, and not be allowed to fall of its own weight in front, or move in any irregular manner. This treatment allows the key to be removed without affecting the adjustment of the action. The horizontal tracker F conveys the motion of the key to the squares and roller-board of the Swell division. The coupler comprises the backfall G, carried by the movable beam H; the sticker I, connecting the backfall with the rear arm of the square D; and the block J, attached to the side of the flat sticker B, and covered with felt on its upper end, as indicated. The front nose of the backfall G is furnished with an adjustment consisting of a tapped-wire carrying a circular button of sole leather, slightly larger in diameter than the thickness of the backfall, as shown. When the coupler is in action, the leather button rests lightly on the felt of the sticker block J. When the coupler is out of action, the beam H is slightly raised, and the front end of the backfall is elevated sufficiently to allow the Great Organ sticker B to move without coming in contact with the adjusting button. This position of the backfall is indicated by the dotted lines. The action of this coupler is extremely

simple. When the Great Organ key A is pressed down by the finger, its tail is raised, and the sticker B is pushed upward against the regulating button of the

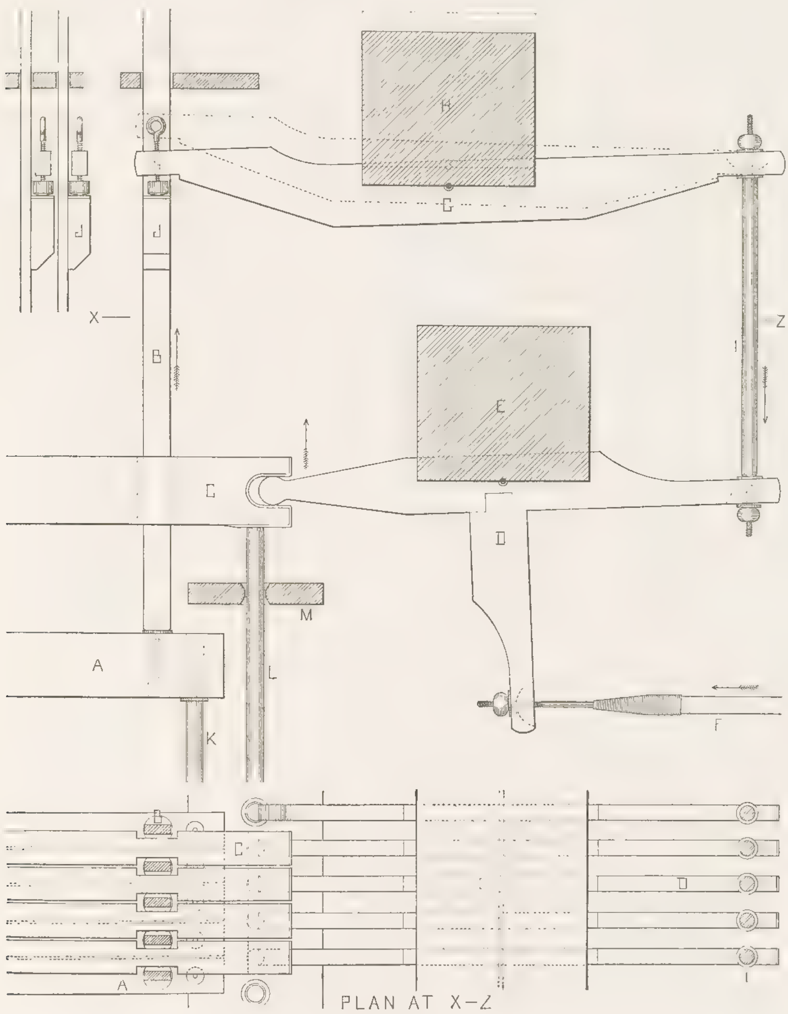


Fig. C.

backfall G, elevating it and depressing the sticker I. This sticker moves the T-square D, which pulls the horizontal tracker of the Swell Organ action F, and at the same time lifts the tail of the Swell key C. The directions in which the several

parts move when the Great key is put down by the finger, are indicated by arrows. The stickers K and L belong respectively to the Great to Pedal and Swell to Pedal couplers. The sticker K is pinned into the tail of the Great key; while the sticker L passes through the stationary register M, and merely presses against the buffing on the under side of the Swell key. This buffing, of smooth leather, is carried into the fork, where it is well black-leaded to eliminate undesirable friction. The rounded end of the T-square should also be black-leaded on its bearing edge.

In Fig. CI. is shown a Swell to Great Unison Coupler, similar in its mode of operation to the preceding, but differing in several details. From the tail of the Great key A rises the flat sticker B, which passes through a mortise in the center of the tail of the Swell key C, and is pinned into the front end of the main backfall D, which conveys the motion to the Great Organ roller-board placed directly over its back end. The horizontal tracker of the Swell Organ E is connected with the key C by the T-square F. The rounded end of the square has its bearing edge covered with leather, and rests on the upper surface of the key where it is held in position by the brass clip G. This arrangement serves the same purpose as the forked key tail shown in Fig. C. The coupling backfall H, carried by the movable beam I, instead of being moved directly by the vertical sticker, as in the coupler previously described, is here linked to the main backfall, immediately behind the sticker B, by means of the tapped and looped wire J. The loop, which is shown in Front View at K, holds the backfall H by the clothed notch in its front end. This notch allows the backfall to be lifted out of action within the loop, as indicated by the dotted lines, without becoming disengaged. The coupler can be easily adjusted by means of the button on the tapped end of the wire. Instead of the wood sticker B, which passes through the mortise in the Swell Organ key, a cranked wire can be employed, passing between the keys of the Swell Organ, as shown at O. The upper end of this cranked wire is inserted in the wood sticker B^1, which is pinned into the main backfall D in the same manner as the sticker B. In Diagram 2, is given a Top View of one Great and three Swell keys; while in Diagram 3, are shown the same keys having the cranked wire arrangement as above described. The operation of this coupler is similar to that previously described. The advantage of this form of action is that by the simple removal of the stickers B, the keys can all be taken out without disturbing the adjustment of any portion of the mechanism. It will be observed that the sticker of the Swell to Pedal Coupler, L, is pinned into the front arm of the T-square; while that of the Great to Pedal Coupler, M, is supported by a fixed register, and simply bears against the buffing on the under side of the Great Organ key A.

The construction of the Swell to Great Octave Coupler, in conjunction with the unison coupler just described and illustrated in Fig. CI., is extremely simple, merely calling for the introduction of a diagonal set of backfalls, a prolongation of the tapped-wires in the tops of the coupling stickers, and additional leather buttons and cloth washers. The disposition of the combined octave and unison coupling backfalls, etc., is shown in the Side View and Plan given in Fig. CII. The keys, Swell T-square, etc., are here omitted, being supposed to be the same in all respects as those shown in the preceding illustration. In Fig. CII., B is the sticker

from the Great Organ key, pinned into the end of the Great backfall D. H is the unison coupler backfall, engaged in the loop of the tapped-wire J, as previously described. O is the diagonal backfall of the octave coupler, its front end being

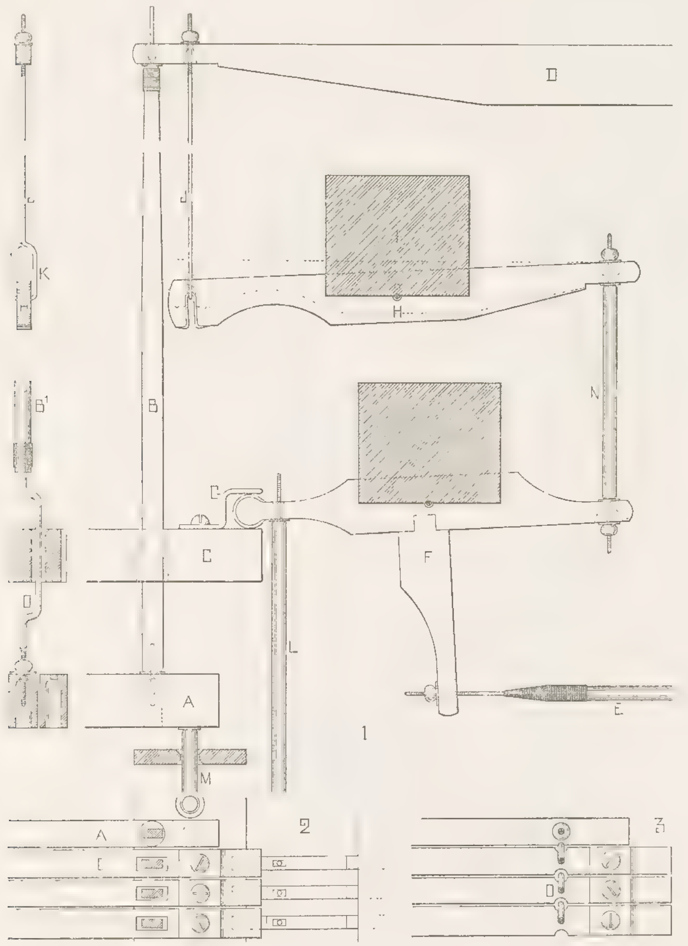


Fig. CI.

forked on the wire J, and its rear end held by the tapped-wire and buttons of the sticker N, belonging to the key of the Swell Organ an octave above. The arrangement of the straight unison and diagonal octave coupling backfalls is shown on

the Plan; the arrangement being understood to be carried throughout the compass of the claviers. Both the coupling backfalls are put out of action by raising their

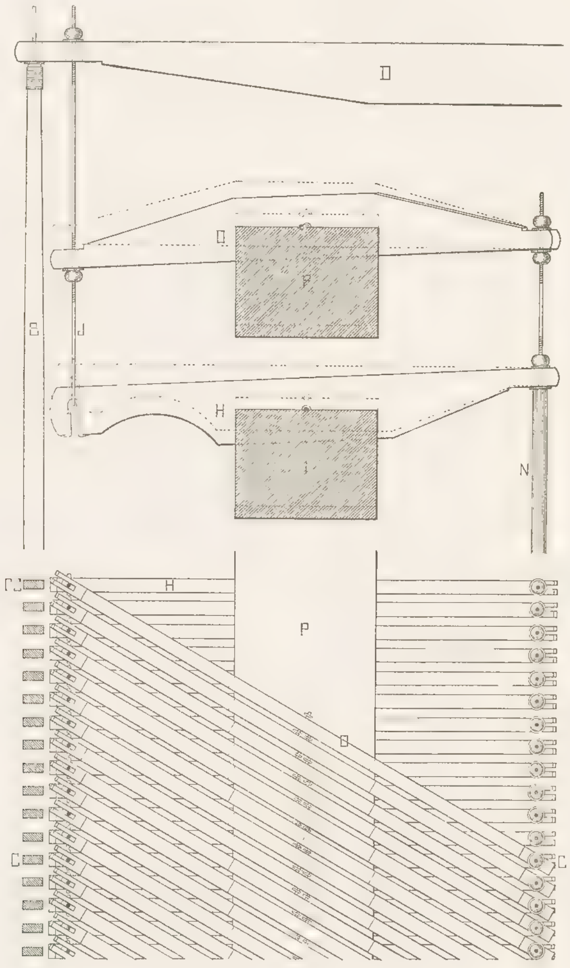


Fig. CII.

respective beams, I and P, sufficiently to elevate their front ends, within the loop and above the lower button of the wire J, to the positions indicated by the dotted lines. While in this position the wire can move, under the influence of the Great

Organ key, without imparting any motion to the coupling backfalls. The unison and octave couplers can be brought into operation independently of each other by the lowering of their respective beams by the draw-stop mechanism provided for that purpose.

The Swell to Great Sub Coupler can be constructed in precisely the same fashion as that above described for the octave coupler, with this single exception; namely, the coupling backfalls have to be carried diagonally from the right to the left, instead of from the left to the right as indicated in Fig. CII.

In all the manual couplers which depend on the operation of backfalls and squares the principles of construction are practically the same, while different dispositions of the parts forming the couplers will naturally obtain—dictated by the manner and direction in which the several key actions are connected with, and carried from, the claviers. It is quite obvious, in the case of tracker actions which are carried from detached and reversed consoles, that manual backfall couplers cannot be located in the immediate vicinity of the claviers. Accordingly, such couplers have to be placed in some convenient position within the body of the Organ where the trackers from the different claviers can be brought into sufficiently close relationship. The best examples of such a treatment are to be met with in French Organs, notably in the larger instruments, where they are connected with pneumatic levers, as in the celebrated Organs in the Churches of Saint-Sulpice and Saint-Eustache, at Paris.

CHAPTER XXI.

THE PEDAL CLAVIER.

THE proper treatment of the Pedal Clavier has for a long time exercised the minds of both organ builders and organists, especially in England; for, while all the more important matters connected with the manual claviers may be said to have been practically settled, there are some very important matters connected with the pedal clavier on which opinions continue to differ in a marked manner: these chiefly relate to the general form of the clavier, and to its position with respect to the manual claviers. One would naturally think, seeing that there can be only one proper position for the performer at the manual keys of every correctly constructed Organ, that there could be no question of any importance raised respecting the most desirable form and position for the pedal clavier, every key of which has to be so disposed as to be readily commanded by his feet, without rendering it necessary for him to change his position. It is surely obvious there can, under such circumstances, be only one *best form*, and only one *proper position*, for the pedal clavier: and it is our purpose, in the present Chapter, to arrive at a conclusion in these matters which shall appear satisfactory from all practical points of view. We shall, however, not attempt to combat opinions held by individuals, and which are born of custom or prejudice: such one-sided opinions, however stubbornly they may be held for a time, will die out, and what is right will ultimately obtain.

As the pedal clavier, historically considered, is not devoid of interest, even if it is only to show that there is no "royal road to learning," a few notes on the subject may be given here. There seem to be good grounds for believing that a pedal clavier of some description was applied to the Organ in Germany about the middle of the fourteenth century; although, as has already been mentioned in our first Chapter, the invention of the *pedalier* has been commonly attributed to a

German organist, of the name of Bernhard, who was in the service of the Doge of Venice between the years 1470 and 1480. Of the form of the pedal clavier when first introduced no record exists, unless we accept the representation of that belonging to the celebrated Halberstadt Organ, given by Prætorius in his "Theatrum Instrumentorum seu Sciagraphia," as depicting its original treatment. This Organ was constructed in the year 1361 by Nicolaus Faber, a priest, and the earliest organ builder whose name has been preserved. The instrument was renovated in the year 1495; and, accordingly, the question arises whether the pedal clavier, as depicted by Prætorius, was made by Nicolaus Faber, or was added at the time of the renovation. Mr. A. J. Hipkins remarks: "Whatever happened in this renovation we shall find that the manual keyboards and compass of the keys were undisturbed, and that probably the pedal keyboard was original, but as to this doubt may be allowed."*

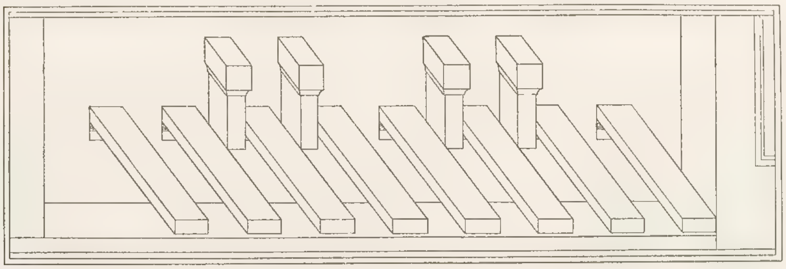


Fig. CIII.

The illustration, Fig. CIII. is traced from the roughly executed woodcut in the "Theatrum Instrumentorum seu Sciagraphia" (plate XXV.). It shows the form of the pedal clavier of the Halberstadt Organ, as known to Prætorius. It will be observed that the compass was only an octave: "B natural, C, C sharp, D, D sharp, E, F, F sharp, G, G sharp, A, and B flat." The natural keys were simply projecting levers or pieces of wood, capable of being depressed by the front portion of the foot; while the sharp keys were slightly projecting toe pedals. Alluding to the office of these pedal keys, Mr. A. J. Hipkins justly remarks: "I believe the deep third keyboard pipes were originally used for drones, and to keep such notes continuously sounding was how pedals first came into use. We call a drone now a pedal-point, and composers use it, especially for the tonic or dominant, with great effect. The Halberstadt pedals were for bass notes to the mixture, and were mixture notes themselves, although without the highest rows of pipes. We may consider the pipes in the side towers were also upon the pedals, but as to this the text is not clear." Such may have been the case in the Halberstadt Organ; but we think there can be no doubt that the earliest pedal clavier was connected

*Third Cantor Lecture, delivered before the Society of Arts, London. February 9, 1891.

with the lower manual, and had no special pipes commanded by it. At what date the pedal clavier became entirely independent of the manual department is not known. For a long time the pedal clavier did not have its compass extended beyond an octave; while its lowest note varied, as in the case of the Organ at Mildenberg, built by Krebs and Mülner, where the pedal compass extended a chromatic octave from A. Toward the end of the fifteenth century the compass was increased. The pedal clavier added, in 1493, to the Organ at Bamberg, built by Conrad Rotenbürger, had the notes "F, G, A, B flat, and then from B natural, chromatically, to the B flat above the bass clef, altogether an octave and a fourth."

The next form of pedal clavier that may be described here, is that commonly designated the "toe pedal board," its keys having to be pressed down in much the same manner as those of the Halberstadt clavier. This is the only form of pedal clavier illustrated by Dom Bedos, in his work, "L'Art du Facteur d'Orgues;" and evidently was the most approved form in use in France at the time he published his treatise—in the year 1766. In Germany the pedal clavier had long before this date, and certainly during the lifetime of Johann Sebastian Bach, assumed a more convenient and practical shape, resembling the imperfect straight

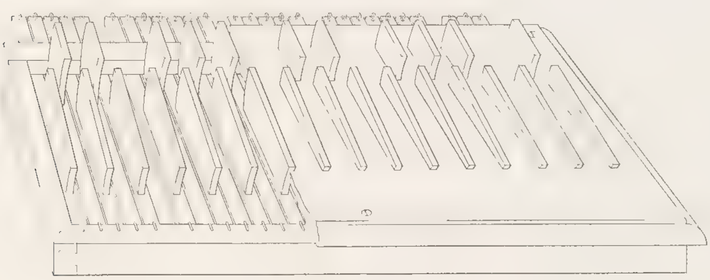


FIG CIV.

treatment which obtains in certain quarters at the present time. The accompanying illustration, Fig. CIV. is a drawing of the toe pedal board, reproduced from the engraving in "L'Art du Facteur d'Orgues." One portion shows the naked keys; while the remaining portion shows the finished clavier, with the playing parts of the keys projecting through slots in the board. This form of clavier may now be classed, along with that of the Halberstadt Organ, among the curiosities of organ-building. It is one that could only remain in use in a country, and at a time, in which pedal playing did not extend beyond the introduction of an occasional pedal-point, or passages of two or three notes in a bar in slow movements. The compass is that which has long been held as ample both in France and Germany; namely, from CCC to D=27 notes.

Turning now to the pages of the most important modern treatise on organ-building in the German language—"Die Theorie und Praxis des Orgelbaues"—we find prominence given to a pedal clavier which presents all the inconvenient features that could well be brought together. Such a clavier would not be tolerated for an hour by any one save an old-fashioned and long-suffering German organist. The keys are straight, short, and of the extreme width possible in the space allowed; and the playing parts of the sharps are only twice their width in length. It would be difficult to imagine a more inconvenient and objectionable arrangement; and the mode of construction represented is as faulty as the design. With these few introductory notes, we may conclude our brief survey of the early pedal claviers; and enter on the consideration, in the first place, of the question respecting the proper position of the pedal clavier with relation to the manual claviers; and on the consideration, in the second place, of all matters relating to the forms and proportions of the pedal claviers used and advocated by representative organ builders and organists at the present time.

In the year 1881 the Royal College of Organists inaugurated a Conference of organists and organ builders to consider and decide matters "with regard to greater uniformity in the external arrangements of Organs;" and as a result of this Conference, the College Council issued a series of Resolutions and Recommendations, which, so far as matters relating to the pedal clavier are concerned, have had most undesirable results. In the full knowledge of what had been done up to that time, it is difficult to understand on what logical arguments and practical grounds some of the Council's Resolutions were arrived at. In condemning these Resolutions we are supported by many of the most celebrated English organists. As this statement will be read by many who may have no direct means of testing its accuracy, we here give extracts from articles and letters which have appeared in the sixth volume of *The Organist and Choirmaster* (London 1898–9). Dr. Charles W. Pearce says: "No organist who has the privilege of frequent intercourse with his professional brethren, can have failed to observe in all directions a growing discontent with the playing arrangements of Organs as they were determined by the College twenty years ago. A letter received by me only a few days ago contains the following sentence underlined: '*The present pedal board is clumsy, awkward, and difficult to use, and is an insult to a good player.*'" Mr. Charles F. South, Organist of Salisbury Cathedral, remarks: "I am sure there are many organists who thought that the 'R. C. O.' came to a most unwise decision when they settled—so far as they could—that the middle CC of the pedals should be under the middle c^1 of the manuals. It has been amusing to me to read that such and such an Organ has been built according to the 'R. C. O. suggestions.' What an enormous amount of harm has been done! The unfortunate players of these instruments have to struggle to get the upper notes on the pedal board in a way that is quite unnecessary. Surely a player ought to sit over the center of the pedals so that the extreme notes will be equidistant." It is only necessary to add that numerous other prominent English organists express similar opinions. For these opinions, we beg to refer our readers to the sixth volume of *The Organist and Choirmaster*.

In the Royal College of Organists' Resolutions we find the following:—

"7. That a plumb-line dropped from the middle c^1 of the manuals fall on the center CC of the pedal board.

"8. That a plumb-line dropped from the front of the Great Organ sharp keys fall two inches nearer the player than the front of the center short key of the pedal board.

"9. That the height of the upper surface of the Great Organ natural key, immediately over the center of the pedal board, be 32 inches above the upper surface of the center natural key of the pedal board.

"10. That the relationship between manuals and pedals be subservient to the fixed relative position of the Great Manual keyboard and the pedal board already defined; it being understood that the position of the Great Manual will determine the position of the other manuals.

"11. That it is undesirable to alter the relative positions of the several manual keyboards as commonly found in English Organs, viz.: Swell above Great, Choir below Great, Solo above the Swell." *

It is somewhat difficult to understand on what arguments the gentlemen forming this memorable Council of the Royal College of Organists arrived at the first Resolution above given: the only possible one appearing to be, that as the lower notes of the pedal clavier are more frequently used than the higher ones, the position of the clavier should be as far to the right of the center line of the manual claviers as practicable. Beyond this there is not one logical argument to be advanced for the Resolution; and it is of very little value, seeing that, in modern advanced organ-playing, every portion of the pedal compass is equally important. On this subject, Dr. C. W. Pearce remarks: "The next question which occupied the Conference was the vertical position of the middle CC of the pedal board with respect to middle c^1 of the manuals. A majority of the members were in favor of this, for the most superficial of reasons, viz., (1) that C under C was not simply an idea but a '*theoretical point* fixed in a musician's mind,' a 'principle which would hardly be *expressed*, but which was *recognized*, and was a feeling which could not be disposed of;' and (2) that as the pedals were principally used from say G to top line A, that therefore the convenience of reaching the high notes *need not* be taken into consideration! The attention of the meeting was further drawn to the fact that the bottom notes of the pedal were then (20 years ago) sometimes heavier of touch than the upper range, and that therefore the player required to be nearer to them. . . . What possible connection there could be between a *theoretical* point or idea, an inexpressible something and a real tangible *practical* question, I entirely fail to see, and the subsequent proceedings of the Conference appear to shed no light on this extraordinary matter. . . . Nowadays we find that we *must* use these self-same upper pedal keys, if we are to perform present-day organ compositions; and, of course, tubular pneumatic and other 'actions' have entirely removed the objection that the lower keys require a heavier pressure of the foot than the upper ones."

* This important question of the relative positions of the several manual claviers is fully discussed in Chapter XIX.

As there can be no possible connection between a "*theoretical* idea, an inexpressible something and a real tangible *practical* question," the Resolution of the Royal College of Organists, on the C under C position, may be pronounced as not only valueless, but objectionable. That such a one-sided position for the pedal clavier, in Organs having a manual compass of from CC to g^3= 56 notes, would prove most awkward and uncomfortable to the performer, properly seated with respect to the manual claviers, admits of little doubt: and it cannot be said that placing the CC key of the pedals directly under the c^1 key of the manual claviers gives the performer the slightest assistance in finding his bearings on the pedals. The simple and common sense, as well as the practical, solution of the problem—if problem it can be called—is to place the pedal clavier, whatever its compass may be, central with respect to the manual claviers, whatever their compass may be. Under such an arrangement, the performer will have an equal control over the lower and the higher keys of the clavier; and will experience no difficulty in finding his bearings. The relative positions of the CC pedal key and the c^1 manual key will vary according to the compass of both the pedal and the manual claviers, while the center lines of both claviers will always coincide. Such being the case we find that, while the center line of the manual clavier, having the compass from CC to g^3, lies in the center of the e^1 key, and the center line of the pedal clavier, having the usual compass of from CCC to F, lies on the surface of the DD♯ key, a plumb-line dropped from middle c^1 of the manual clavier will fall between the CC♯ and DD pedal keys, close to the side of the latter. Again, while the center line of the manual clavier, having the extreme compass of from CC to c^4, lies on the center of the f^1♯ key, and the center line of the pedal clavier, as above mentioned, lies on the surface of the DD♯ key, a plumb-line dropped from the c^1 manual key will fall between the CC and CC♯ pedal keys. Again, while the center line lies on the center of the f^1♯ key of the manual clavier, as above described, and the center line of the pedal clavier, having the extreme, modern compass of from CCC to G=32 notes, lies on the center of the EE key, a plumb-line dropped from the c^1 manual key will fall between the CC♯ and DD pedal keys.

It will be seen, that of the three propositions just given the second, which embraces a manual clavier of 61 notes and a pedal clavier of 30 notes, approaches nearest to the C under C position; but here it is simply the result of the central disposition. As our propositions embrace both the minimum and maximum compasses of the manual and pedal claviers, we have not considered it necessary to make any allusion to the relative positions of the two pedal claviers when associated with a manual clavier having the compass of CC to a^3=58 notes. We have also omitted the consideration of the favorite German pedal compass—CCC to D=27 notes—simply because there is no likelihood of so objectionable a compass ever being adopted for English or American Organs.

The Resolution of the Council of the Royal College of Organists, "That it is undesirable to alter the relative positions of the several manual keyboards as commonly found in English Organs, viz., Swell above the Great, Choir below the Great, Solo above the Swell," is open to grave question. But as this subject is

treated at considerable length in the preceding Chapter on the Manual Claviers, it is unnecessary to say more in this place than that we consider this Resolution as worthless as that which pronounces in favor of the C under C position. The Council of the College, in another Resolution, says: "That a plumb-line dropped from the front of the Great Organ sharp keys fall two inches nearer the player than the front of the center short key of the pedal board." This is followed by the Resolution "That the height of the upper surface of the Great Organ natural key, immediately over the center of the pedal board, be 32 inches above the upper surface of the center natural key of the pedal board." To readily assess the value of these Resolutions, one has to substitute the term Second Manual for the term "Great Organ;" for no notice is taken of the innumerable Organs which comprise only Great and Swell divisions in their manual departments, and which invariably have their Great divisions commanded by their lower claviers. No notice is likewise taken of those important Concert-room Organs and other instruments whose Second Manuals do not command their Great divisions.

With respect to the rule laid down by the Resolution, which places the front of the center sharp key of the pedal clavier two inches back from a plumb-line dropped from the front of the sharp keys of the Second Clavier, it is only necessary to say that it can only be approximately correct for one special form and disposition of the manual claviers. We presume the form and disposition of the claviers contemplated in this Resolution are those set forth in another Resolution, which reads as follows: "That the length of the manual natural keys be five and a half inches, and the amount of overlapping of the upper manual keyboards be one and a half inches."

According to these measurements, the front of the center sharp key of the pedal clavier would be six inches back from a plumb-line dropped from the nosing of the natural keys of the lowest manual clavier; allowing that the natural keys extend two inches in front of the black or sharp keys. It is from the nosing, or front line, of the lowest clavier that the position of the pedals should invariably be calculated; and not from a point that may change considerably in different groups of claviers. The pedal clavier has no special relation to the Second Manual, even when it commands the Great Organ; while it has to the lowest clavier, or First Manual, which forms the advanced line of the entire group of claviers, and is closest to the body of the player.

On the subject under consideration, Mr. R. H. M. Bosanquet passes some interesting remarks.* He says: "The height from the middle of the pedals to the Great Organ keys, it is agreed, should be 32 inches. But as to the forward position there is a difference. The Resolutions [R. C. O.] say that 'a plumb-line dropped from the front of the Great Organ sharp keys falls 2 inches nearer the player than the front of the center short key of the pedal board.' The old arrangement gave usually 1½ inches for this distance. But it is thought that the change has not gone far enough, and 4 inches has been found preferable. There is scarcely any single arrangement which is so important for the comfort of the

*Article "ORGAN," in the "Encyclopædia Britannica."

player as having sufficient space in this direction." In the accompanying diagram, Fig. CV., Mr. Bosanquet shows the three different arrangements he alludes to in the above remarks. According to the dimensions here given, and accepting the relative positions of the manual claviers as approved by the Royal College of Organists, the respective distances of the center short key of the pedal clavier back from a plumb-line dropped from the front of the lowest manual clavier, are 7½ inches, 8 inches, and 10 inches. We strongly recommend the adoption of the last measurement, which, according to Mr. Bosanquet, has been found preferable to that advocated by the Royal College of Organists twenty-three years ago. We feel certain that organists will find it very convenient, especially in connection with radiating and concave pedal claviers.

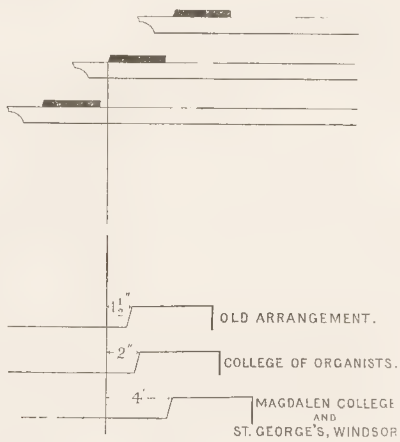


Fig. CV.

In America, where straight, and generally flat, pedal claviers may be said to have been used exclusively up to the year 1903, the measurements of the Royal College of Organists have been adopted to a large extent, and alluded to in organ specifications as if they were on a par with the law of the Medes and Persians. Of course one can easily understand the readiness of organ builders to adopt the College "Resolutions," seeing that they recommend the cheap and very easily constructed straight pedals, but it is not so easy to understand why American organists remained, so long and to a very large extent still remain, satisfied with so awkward and illogical a form. We have obtained measurements from several representative American organ builders, and find that they all agree in adopting the distance of 32 inches between the natural keys of the pedal clavier and the upper surface of the natural keys of the Great Organ clavier, whether the latter occupies the central position in a three manual instrument, or the lowest position in an instrument of only two manuals. And they practically agree in

placing the center sharp pedal key 4 inches back from a plumb-line dropped from the ivory nosing of the Great Organ clavier. One builder slightly exceeds this measurement in his Organs.

A pertinent question here presents itself, which is not touched upon in the "Resolutions" of the College, but which deserves some careful consideration at this time when improvements, *of a mechanical nature*, in organ construction are occupying the attention of so many organ builders and experts. The question is this: If in the case of the group of three manual claviers, in which the Great Organ clavier occupies the middle position, the center sharp key of the pedal clavier is placed 8 inches back from a plumb-line dropped from the ivory nosing of the lowest, or Choir Organ clavier; then why, when the Great Organ clavier occupies the lowest position, as in the case of two manuals only, is it considered sufficient to place the center sharp key of the pedals only 4 inches back from a plumb-line dropped from the ivory nosing of this lowest manual clavier? This somewhat inconsistent practice, which appears to generally obtain, cannot well be defended on any practical or logical grounds. In the first place, the pedal clavier has no closer relation to the Great Organ clavier than to any other manual clavier; while, in the second place, the position of the performer in relation to the lowest and most advanced manual clavier, in instruments of two or three manuals, will, or should be, practically the same. Such being the case, why should the sharp keys of the pedals in the one instance be four inches nearer him than in the other? Again, if the measurements are to be invariably taken from the Great Organ clavier, why has no provision been made for the possible and, we venture to think, desirable alteration of its position in groups of three or more claviers? We are led back, by all the above considerations, to what we have already said; namely, that all calculations between the manual and pedal claviers should be made from the lowest and most advanced manual clavier, without any regard to the division of the Organ which it may command.

Having considered matters relating to the relative positions of the pedal and manual claviers calculated from vertical lines, we have now to speak of their relative positions in the horizontal direction; or, in other words, of the distance which should obtain between the playing surface of the pedal keys and that of the manual claviers. Here, again, we find in the usual practice, founded on the ninth "Resolution" of the Royal College of Organists, an undesirable want of uniformity in instruments of two and three manuals. According to this practice we find, in the case of two manuals, that the distance from the surface of the ivory keys of the lowest and most advanced clavier to the playing surface of the center natural key of the pedal board is 32 inches; while, in the case of three or more manuals, the distance between the lowest clavier and the center pedal key is only from 29 inches to 29½ inches, according to the distance between the ivory platings of the manual claviers. It is difficult to understand why the distance from the pedal key is always calculated to the Great Organ clavier, whatever its position may be with respect to the claviers of the other divisions of the instrument. It certainly seems absurd that while in the group of three manuals the lowest one is located 29½ inches above the center pedal key, the lowest of two manuals should be placed at

the distance of 32 inches. We are of opinion that as 29½ inches is a perfectly convenient height for the lowest clavier above the center natural key of the pedal clavier, it should be universally adopted, irrespective of other considerations relating to the number or arrangement of the claviers. In the case of two manuals, the Great Organ clavier will invariably be the lowest and nearest to the performer; while in groups of three, four, or five manuals, the lowest clavier will either be that of the Choir Organ or Great Organ—preferably the latter. We are glad to be able to state, in support of our argument, that several of the more progressive English organ builders have adopted the measurement of 29½ inches for two manual Organs. This is a most desirable step toward uniformity of measurement.

We now come to the consideration of matters of great importance; namely, the forms and proportions of the pedal clavier: and we shall commence with a description of the simplest and most inconvenient form, and subsequently treat of the other forms in their order of merit.

The first step from the primitive clavier, as it obtained in the ancient Organ at Halberstadt, and illustrated in Fig. CIII., was probably a similar arrangement of "toe pedals" as that given by Dom Bedos, and shown in Fig. CIV. From this form the next step was to the clumsy, straight pedal clavier, met with in old German Organs, and which is alone illustrated in the latest important German treatise on Organ-building,* as if it was all that could be desired. Only a little better than this objectionable form is the straight pedal clavier, which has, until very recently, been almost exclusively made by American organ builders, and willingly accepted by American organists, probably because the country has not been fortunate enough to produce a Henry Willis. This straight pedal clavier has very commonly been constructed with short sharp keys in a straight line, presenting the maximum of inconvenience to the performer. The slightly improved form of this clavier is illustrated in Fig. CVI. In this form, all the keys are parallel and level, the sharp keys being gradually advanced as they leave the center of the clavier, their fronts coming to a curved line, which brings the extreme sharps about 2 inches further forward than the central sharps. In the Plan, the toe-board is shown straight, but in some instances it is made to follow the curve of the sharp keys, so as to have these keys all of one length. Such a treatment, however, does not in any way improve the pedal clavier in a practical direction. The usual distance from center to center of the natural keys is 2½ inches; but, realizing to some extent the inconvenient form of the pedals, certain builders adopted the measurement of 2⅜ inches, which does not to any appreciable extent interfere with the action of the performer's feet, while it considerably reduces the width of the pedal clavier. In the illustration this latter measurement obtains. The thickness of the keys is usually ⅞ inch. The forms of the natural and sharp keys vary slightly in the works of different makers; but those shown in the Section, in Fig. CVI., may be accepted as the most generally approved. This drawing is an exact representation to scale of the standard pedal keys adopted by the late Roosevelts, of New

* "Die Theorie und Praxis des Orgelbaues," by Töpfer-Allihn. Weimar, 1888.

York. It will be observed that the playing surface of the natural key is not straight, as is usual in English and German pedals, but slightly raised toward its center. This part of the key was usually made of holly, a very close-grained durable white wood, glued to the hardwood body of the key. In like manner the playing portion of the sharp key was sometimes constructed of ebony or rosewood, glued to the hardwood body. So far as appearance was concerned such pedals

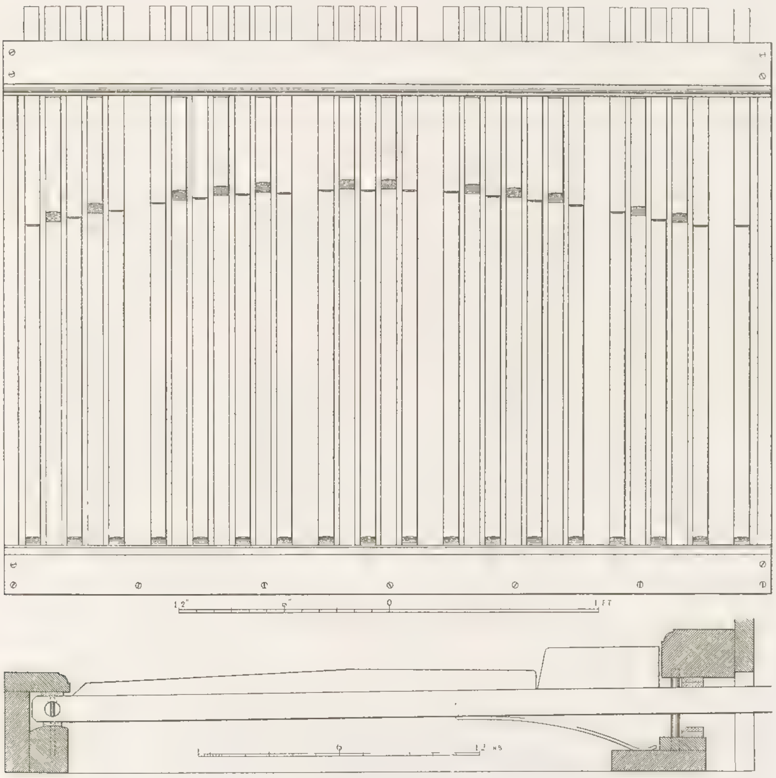


Fig. CVI.

left little to be desired. Of course, in inferior work such valuable woods as holly, rosewood, and ebony are never used. In the Roosevelt standard pedal clavier the sharp keys are all of one length, namely, that shown in the Section; and, accordingly, the pedal clavier may be said to present the maximum of inconvenience to the performer occupying the proper position at the claviers.

The next step in advance of the somewhat primitive form of pedal clavier just described, is that advocated by the Royal College of Organists in the following Resolutions:

"1. That the compass of the pedals be from CCC to F, *i. e.*, 30 notes.

"2. That the pedals be parallel.

"3. That the pedals be concave, with radial top facings; and that the concavity be the arc of a circle, having a radius of eight feet six inches.

"4. That the length of the center natural key of the pedals be not less than twenty-seven inches.

"5. That the fronts of the pedal short keys form an arc of a circle, having a radius of eight feet six inches; and that the length of the center short key of the pedals be not less than five and a half inches.

"6. That the pedal scale be two and three-eighths inches from center to center of two adjacent natural keys."

The drawings given in Fig. CVII., accurately represent the pedal clavier constructed in conformity with the above six "Resolutions." It may be pointed out, however, that "Resolution" 3 simply requires that the pedal keys are to have their "top facings," or playing surfaces, radial, clearly implying that the key bodies are to move vertically. We have, accordingly shown the clavier so formed, and as delineated in Mr. F. E. Robertson's "Practical Treatise on Organ-Building."

While there can be no question that the College clavier is greatly superior, from every point of view save that of expense, to the radically imperfect American form, it was evidently adopted as a compromise between the objectionable flat pedals and the desirable form systematically constructed and invariably used by England's greatest organ builder. It is easy to divine, although it is not for us to presume to state, the reasons or influences which led the College to promulgate such very unwise instructions on so important a matter. That they were unwise is very freely admitted by those lights in the organ-playing world to-day who have had the best means of judging, and have every right to express their views with authority. It is a mystery to us that common sense and ordinary observation did not lead to their being emphatically condemned, at least by organ players, twenty years ago. That organ builders generally were quite content to abide by the College dicta can be very easily understood; the College pedal clavier was comparatively inexpensive and easily made, and that was enough to secure their approval. At the present time, however, in which greater interest is being taken in, and much more attention is being paid to, matters of organ construction, we may expect to see radical changes in details that imperatively call for improvement.

Notwithstanding the fact that England is the only country in which concave pedal claviers are systematically constructed and used, it appears certain that their introduction was due to a German organ builder. Herr Schulze, of Paulinzelle, sent to the Great Exhibition of 1851 an Organ fitted with a concave pedal clavier; and we cannot find a record of an earlier appearance than this. We did not see this Organ; nor can we obtain any description of the pedal clavier, beyond the fact that its keys were parallel and arranged in concave fashion. We presume, as

no mention has been made of the sharp keys, that they were all of the same length, as in the ordinary German pedals. As we shall have to allude to the parallel and concave pedal clavier during the following discussion on the merits of the radiating and concave pedal clavier, we may leave it for the present and without further description.

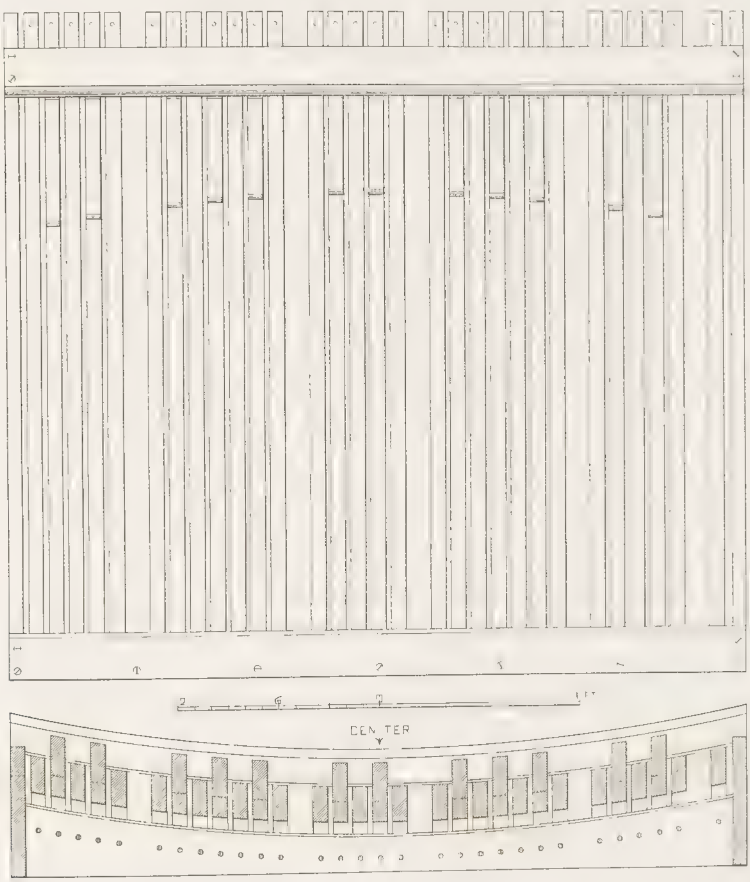


Fig. CVII.

It has been stated, and apparently on good authority, that the principle of radiation was first applied in the construction of the pedal clavier by Elliott, the English organ builder, in the year 1834. But it was left to the late Henry Willis,

the most renowned English builder and an organist of consummate skill, to produce the most sensible and perfect pedal clavier that has been constructed up to now in England, by combining the radiating and concave principles of formation; giving to the world what is now commonly known as the "Willis pedal board."* In the construction of this, Mr. Willis is said to have acted on the suggestion of Dr. S. S. Wesley: and under the direction of the latter it was applied to the Grand Organ in St. George's Hall, Liverpool, built in 1855. Whatever circumstances may have led to the inception of the radiating and concave pedal clavier, it is quite certain that the form and proportions in which we now find it in the more satisfactory examples were worked out by Mr. Henry Willis. Since its introduction in the great Liverpool Organ, Mr. Willis and subsequently the firm of Messrs. Willis & Son have systematically applied their radiating and concave pedals to the Organs constructed by them, wisely ignoring the "Resolutions" of the Royal College of Organists. The late Mr. W. T. Best, an authority on all matters relating to the pedal department of the Organ that few who have known him and his matchless command of the pedal clavier will think of questioning, was a staunch advocate for the adoption of the radiating and concave clavier.

In the accompanying illustration, Fig. CVIII., are given the Plan and Transverse Section of the radiating and concave pedal clavier, in its usual form, and with the compass of 30 notes. Both the radiation and concavity are on arcs having the radius of eight feet six inches. This radius has been found to be generally acceptable, although it seems probable that a modification might lead to the production of a pedal clavier better calculated for universal adoption. On this question we speak more fully later on. The Plan, 1, given in Fig. CVIII. shows the radiating and concave clavier with the keys placed vertically, and not radiating to the central point of the concave arc as all the keys are shown in the Transverse Section, 2. Although the keys of concave claviers are sometimes placed vertically, in the Plan here given they are so drawn for the purpose of avoiding the undesirable confusion which would attend the introduction of a great number of apparently conflicting lines. In certain forms of this pedal clavier the toe-board A has its front carried straight instead of following the radiation arc, as shown. This simply causes the sharp keys to be made longer as they recede from the central DD♯ key. There is some advantage in such elongation. The Section is supposed to be cut through the clavier close to the front of the toe-board A: here any indication of the radiation at the further ends of the keys, as they pass through the register, has been avoided to prevent apparent confusion.

There can be no question that from whatever point of view the pedal clavier is contemplated, the radiating and concave form occupies the front-rank. It is the only one that is adapted to the natural and easy movements of the legs and feet of the performer, seated steadily and in the proper position at the manual claviers. The pedal passages which are executed with considerable difficulty, and with the maximum amount of undesirable movement of the body, on the parallel pedals, can

* The advantages of this form of pedal clavier were so patent to us that so far back as 1868 we adopted it for the Chamber Organ we were then engaged in constructing: and we subsequently found no reason to regret our selection, although we were not blind to its obvious shortcomings.

be played with ease and grace on the radiating and concave clavier. To those who have a prejudice, through long custom, in favor of the parallel pedal clavier, or who have had no opportunity of becoming acquainted with the advantages of the Willis pedal clavier in its original or modified form, the above dogmatic statements

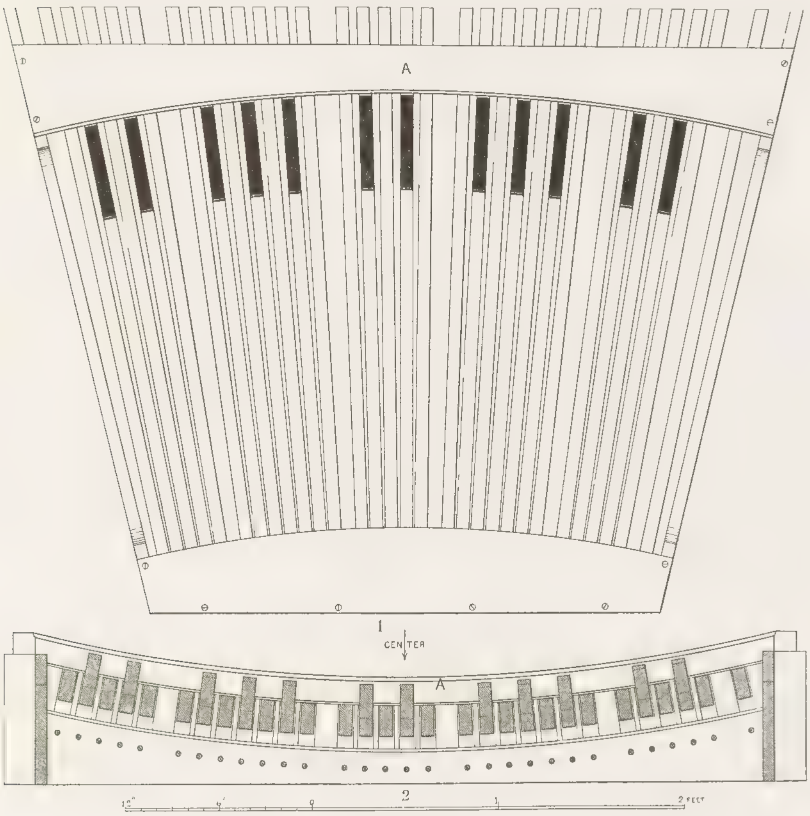


Fig. CVIII.

may seem to require some support; accordingly, to those persons the following remarks will be interesting.

During recent years there has been a growing discontent in the higher or more advanced organ-playing circle in England with the pedal clavier advocated by the Royal College of Organists in 1881; and this feeling of dissatisfaction found effective voice, on the initiative of Dr. C. W. Pearce, in the columns of *The*

Organist and Choirmaster of July 15, 1898. In his initiative article Dr. Pearce, after briefly alluding to the "Resolutions" and "Recommendations" of the College, says:—

"These resolutions and recommendations were wholly or partially adopted by certain organists and builders at the time they were first published; and since then, the growing popularity and influence of the College have gained for them a still wider recognition. But the fact remains that they did not meet with *universal acceptance* in 1881, nor do they receive it now, and it is at the best an open question whether they will ever be generally adopted."

We venture to say that there is not the slightest chance of them ever being generally adopted; and it is far from being desirable that they should be. Dr. Pearce continues:

"The need of greater uniformity in the external arrangements of Organs therefore exists *now*, quite as strongly as it did twenty years ago. The points then voted upon deserve equal or even greater discussion at the present day. Why? Because organ-building, organ music, and organ playing, have each and all made enormous strides since the College of Organists met in earnest conference to decide what constructive arrangements should be absolutely uniform, and what other points of detail should be left open for the exercise of individual taste and option. Again, many of the organists and others who then met and so strongly protested against certain things are no longer with us. Many are either dead or retired, others may have changed or modified their views, so that it is manifestly unfair to present and future generations of players and builders, that the old-fashioned opinions and prejudices of our predecessors should be allowed to become fossilized, and to be handed down to posterity as a kind of law of the Medes and Persians, infallible, unaltered, and never to be spoken against. . . .

"No organist who has the privilege of frequent intercourse with his professional brethren, can have failed to observe in all directions a growing discontent with the playing arrangements of Organs as they were determined by the College twenty years ago. A letter received by me only a few days ago contains the following sentence underlined:—'The present pedal board is clumsy, awkward, and difficult to use, and is an insult to a good player.' . . .

"The last College Conference has already done immense good in one respect at least; whereas in 1881 there were many kinds of pedal boards to be considered, most of these [including all the objectionable flat varieties] are now happily disposed of, and we are chiefly (if not exclusively) concerned with two only, viz., those respectively known as the 'College' and the 'Willis' boards. The College pedal board is (1) parallel and concave, and (2) with the fronts of the short keys forming the arc of a circle, it is so arranged that the center CC of the pedals is directly under middle c^1 of the manuals. The two circles, that of concavity and that of which the fronts of the short keys may be said to form an arc, are each intended to have a radius of 8 ft. 6 ins. These are the special features of the board upon which we now invite discussion. The Willis pedal board (invented by the late Dr. S. S. Wesley, and used by the eminent builder Mr. Henry Willis in every Organ erected by him during the last forty years or more) is radiating and concave, and is considered by many of our most distinguished British organists to be by far the better and more convenient of the two, because the upper extreme of the pedal clavier being brought nearer to the player, the high notes are much easier to reach than they are upon the College board. This most desirable convenience is not arrived at solely as the result of radiation, but from the fact that C is not placed under C but is located further to the left. I was not a member of the College of Organists in 1881, and was therefore not present at a single meeting of the Conference; but I am writing with a full report of the proceedings before me, and am consequently

able to open the discussion by briefly explaining how the present College pedal board came to be evolved and adopted. To Mr. (now Dr.) F. J. Sawyer, of Brighton, belongs the honor of opening the ball by stating that a radiating board is easier to play upon, because the foot, when moved either way with the heel as a pivot, describes a fan-like figure. This was at once objected to by a speaker, who remarked that by giving the leg a pendulous motion the foot indeed rises at the beginning and end of each swing, but that the toe does not turn out in the direction indicated by a radiating board, the circle described on the pedals being solely vertical, and in no sense a horizontal one. It was further urged that with radiating pedals, the distances between notes forming the same intervals were not identically the same throughout the entire range of the board, and that the use of the heel in pedaling was found to be awkward from the smallness of some of the spaces between the notes. There happened to be present a majority of members in favor of straight pedals, and accordingly the verdict was given in favor of the straight but concave pedal board.

"The next question which occupied the Conference was the vertical position of middle CC of the pedal board with respect to middle c^1 of the manuals. A majority of members were in favor of this, for the most superficial of reasons, viz., (1) that C under C was not simply an idea but a '*theoretical point* fixed in the musician's mind,' a 'principle which would hardly be *expressed*, but which was *recognized*, and was a feeling which could not be disposed of;' and (2) that as the pedals were principally used from say G to top line A, that therefore the convenience of reaching the high notes *need not* be taken into consideration! The attention of the meeting was further drawn to the fact that the bottom notes of the pedal were then (20 years ago) sometimes heavier of touch than the upper range, and that therefore the player required to be nearer to them. The 'pendulous motion' of the leg appears to have met with a good deal of derision from eminent organists outside the Conference, but their remarks in the musical press of the day carried no weight at the discussions. It was gravely pointed out in a letter addressed to the editor of the *Musical Standard*, that unless the resolutions were carried by a *very considerable majority* of the members, they would be of little real value in future proceedings. The same writer proposed that the sense of the whole body of members could be taken by means of proxy papers, but this suggestion was not carried out.

"What possible connection there could be between a *theoretical* 'point' or 'idea,' an 'inexpressible something' and a real tangible *practical* question, I entirely fail to see, and the subsequent proceedings of the Conference appear to shed no light on this extraordinary matter. Yet mainly for this reason, and because it was asserted that the upper pedal keys were of no actual use (why were they ever put there?), the convenient and common-sense 'Willis' pedal board was rejected. Nowadays we find that we *must* use these selfsame upper pedal keys, if we are to perform present-day organ compositions; and, of course, tubular-pneumatic and other 'actions' have entirely removed the objection that the lower keys require a heavier pressure of the foot than the upper ones. It therefore seems necessary that newer and more up-to-date reasons must be given for the retention of the present College pedal board. What are these reasons? And if it really *is* easier to play upon a College than upon a Willis pedal board, *why* is it easier? It may be that the *ideal* pedal board has even yet to be invented."

It was thus that Dr. C. W. Pearce ably opened the discussion on the desirable form for the pedal clavier which was subsequently carried on in the columns of *The Organist and Choirmaster*, and from which we extract the following remarks and opinions by distinguished organists and experts. The first authority to follow Dr. Pearce was Mr. Charles F. South, Organist of Salisbury Cathedral. After remarks respecting the "unwise decision" arrived at by the College of Organists respecting the C under C position, which we have already quoted in the earlier part

of this Chapter, he says: "A radiating and concave pedal board does seem to be the most natural thing. Why should there be two pedal boards? I can speak from about twenty-six years' experience that a 'Willis' pedal board is the pedal board to play on; you don't want to find the notes, they seem to find *you!* Henry Willis has done much, *very much* for organists, and he can still play [1898] in a way that many players would envy. I do hope that the R. C. O. will soon hold a meeting, and rescind a Resolution that ought never to have been arrived at."

An experienced organist, writing under the *nom de plume* "Tuba," says: "In my opinion there is no doubt that, both theoretically and practically, radiating pedals are correct. Let any one sit on an organ stool and stretch his feet out to bottom C and top F, and see the position taken by toe and heel of each foot; undoubtedly it is radiating. It is in fact difficult and even painful for a man with short legs to place his *heels* on both these notes simultaneously on a College board, but quite easy on a Willis. But I think the time for theorizing has gone by, and the subject should be set at rest once and for all by practical tests. Of course any change of pedal board is disturbing to an organist until he gets used to it, whether it be better or worse than the one he is used to, and there are doubtless many who have had only a slight acquaintance with the Willis board, such as on the occasion of giving recitals on strange instruments, but this is not sufficient test. The only real way for an organist to satisfy himself on the point, is to have a Willis board fitted to his instrument, and to play on that and no other for two or three weeks, until he is quite familiar with it, then let him go back to the College board, and see the difference. But this is of course much easier said than done. Perhaps the R. C. O. might have an alternative set of Willis pedals fitted to their Organ, so that both they and their students could give it a thorough trial. I know my master, a Mus. Doc., and F. R. C. O., one of the strictest of his sect, would not hear of my having the radiating board when I was studying with him, as he said they were contrary to R. C. O. teaching, and it was only some years after, when I had a Willis board attached to my instrument that I realized how the difficult passages seemed to disappear, and how much more certain and secure I felt when playing extreme passages.

"Willis does not put C under C, but D under D, which is quite another thing, especially now the pedals are going up to G, 32 notes, as in the new specification at St. Paul's. If this is to be the compass of the pedals in future, viz., CCC to G, then radiation will be absolutely a necessity. . . . Willis also raises the sharp keys so that they slope upwards toward the instrument, consequently the foot feels the whole note comfortably and not just the point; this gives a feeling of great security and pleasure in playing. Personally I hope the Willis board may soon be recognized as the standard pedal board throughout the whole of the country."

Mr. Thomas Adams, Organist of St. Alban's, Holborn, London, writes very much to the point in the following short letter: "The pedal board advocated by, and bearing the name of the 'College of Organists' is, in my opinion, 'a fond thing vainly invented.' Mr. Henry Willis has, for many years past, supplied a pedal clavier infinitely superior, since it alone permits the foot to work in a natural and graceful manner."

While many similar opinions might be quoted from the pens of distinguished organists and experts, we need not now do more than quote Dr. C. W. Pearce's summary, published at an early stage of the discussion, but which might, with equal propriety, have been issued at its close. Dr. Pearce remarks :—

"Up to the present, the few letters received by us have been mostly in favor of radiating and concave pedals, for these reasons:

"1. The player sits over the center of the pedals (which is an impossibility where C is under C).

"2. The Willis board is easier to play upon because it meets the actual natural radiation of the feet.

"3. It is therefore more convenient for playing difficult pedal passages.

"4. It does away with the necessity of movable seats, or of holding on for dear life to the sides of the organ stool during the performance of, say, the pedal solo in Bach's Toccata in C.

"5. It is quite easy to play the highest and lowest notes with the right and left heels respectively.

"6. As the pedal board is slowly but surely extending its upward compass, and modern organ music demands the employment of these high notes, it seems highly probable that at no very distant date, the R. C. O. board will have to be modified in some way or other. The Willis board, on the other hand, *satisfies* these new conditions, being entirely 'up-to date.'

"These reasons must appear to any impartial reader to carry weight; at any rate, they are really *reasons*, and neither excuses nor apologies. Now, what can be said in favor of the R. C. O. board?

"1. It *is* the R. C. O. board, the one sanctioned by the most eminent body of organists in the world, and popularized by nearly twenty years' use.

"2. It *must* be played upon by every person who desires to become A. R. C. O. or F. R. C. O.

"3. It is said to be used far more extensively than the Willis board, and that therefore the minority of organists who prefer radiation should give way to the majority, who are not accustomed to it.

"4. It is not easy to see what is wanting in the R. C. O. pedal board.

"5. The C under C system satisfies a 'theoretical *idea*' which is said 'to exist in every musician's mind,'—an *inexpressible* something, but still—a something.

"This seems to us to be a fair statement of the rival claims so far as they have been presented to us by our correspondents and others. We should really like to get an authoritative communication pointing out, clearly and unmistakably, the real advantages to be gained by using R. C. O. pedals."

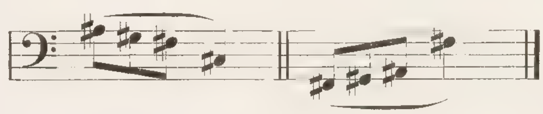
It is quite unnecessary to remark that no such "authoritative communication" on the subject has been forthcoming up to the present year of Grace 1904.

While it is quite easy to understand why groove-loving organ builders prefer the straight pedal clavier, it is somewhat difficult to account for the preference shown by organists, in some quarters, for the form of pedal clavier that presents the maximum of inconvenience to the performer. The force of habit is very strong; and once an organist becomes accustomed to a pedal clavier, even of the worst of all forms now in use—that met with in the great majority of American Organs—it is difficult to convince him that it will be to his advantage to change. He is naturally reluctant to get out of the rut he has so long been in, even though he knows such action will lead to better things. It is quite evident

that in Great Britain the Royal College of Organists' pedal clavier (which is a great improvement on the old-fashioned straight and flat pedal clavier so long used in Germany and the United States) is doomed; and the English organists are to be congratulated on having so emphatically condemned it. In the discussion previously touched upon, not a single satisfactory reason was advanced in favor of the straight and concave clavier. The only argument which showed itself was based on a reluctance to change, and to undertake the small amount of practice necessary to become familiar with the radiating and concave clavier. We have observed, with surprise and regret, that organists generally do not take the interest they ought to take in matters of organ construction. To them every detail, both of tonal and mechanical appointment, should be full of the deepest interest: and we can only hope that our humble labors in the present work, will induce many organists to study the science and art of organ-building, and so aid the further development of the noble instrument on which they make music.

During the discussion which appeared in the columns of *The Organist and Choirmaster*, certain suggestions were made by experienced organists for improving the present form of the radiating and concave clavier; and, as "in the multitude of counselors there is wisdom," such suggestions deserve to be carefully considered.

The first suggestion of importance is that made by "Tuba," who advocates the lengthening of the sharp keys. He says: "It seems to me an anomaly, that while we are able to use both toe and heel on the white keys, we can only, at present, use our toes on the sharp keys. Therefore I would suggest lengthening the latter to nine or ten inches instead of six and a half as in the present Willis board. This would enable one to play such passages as the following quite smoothly and rapidly:—



and in fact make the sharp keys quite as easy as the white in every combination, because one could play either group of these sharp notes with the heel and toe of one foot. It would not do to lengthen the keys in the direction of the player, as that would preclude him from using his heels on the white keys, and would destroy his balance; but the sloping (Willis) pedal might be carried over the frame right up to the front board of the instrument. It would possibly entail an increase in the angle of slope of key, but I believe Mr. Willis himself thinks that this might be done to his present board, with advantage, to the extent of an inch."

A writer who signs himself "W. E. B.," suggests making the concavity of the pedal clavier "an arc of a lesser circle than at present, *i. e.*, to give a greater rise at each end, say another inch." The same writer adds: "As a means of overcoming the difficulty of playing three short pedal keys in succession, may I suggest the A♭ be brought forward ¼ or ⅜ of an inch more than G♭ or B♭? In general

playing, the slight projection would be no obstruction, but in playing large intervals the organist's foot, which acquires an unusual sensibility, would 'find' it directly."

In connection with this latter subject, Dr. Charles Vincent makes a suggestion (at an earlier date—April 15th, 1898), which deserves the consideration of organists and organ builders. "All organists have doubtless experienced the difficulty of executing smoothly on the pedals the three notes F sharp, G sharp, and A sharp (or their harmonic equivalents) when following one another in ascending or descending passages. The G sharp, or A flat, is always a difficult pedal to put down in whatever passage it occurs, and only the most experienced performers are able to play this note with certainty, when the music is in a quick *tempo*. By a simple contrivance I find these difficulties can be entirely overcome, and G sharp instead of being the most difficult pedal to play becomes the easiest.

"The contrivance consists of a slight addition to the pedal board which can be made by any one in a very short time. Cut out two pieces of wood about 4½ inches long, 2 inches wide, and ¾ of an inch thick; screw these to the two G sharp pedals, at the end beneath the stool, these pedals will then have raised portions at both ends; the piece of wood to be fixed need not be as large as the ordinary raised portion of a sharp or flat key. By adopting this device the difficult passages quoted at the beginning can be executed smoothly by alternate feet with the greatest ease, and all skips to the A flats or G sharps, can be made with certainty. "I venture," concludes Dr. Vincent, "to make this suggestion for the consideration of organists who have found that F sharp or B flat *will* sometimes sound, when the player only intended the foot to strike G sharp or A flat."

After a long study of the subject, and a careful consideration of the above and many other suggestions that have come under our notice, we have arrived at the conclusion that while the Willis radiating and concave pedal clavier is at the present time the most convenient and sensible one in use, it is possible to modify its form or proportions to such an extent as to recommend it for general adoption, and ultimately, let us hope, to the complete supersession of all classes of parallel-keyed pedal claviers.

As the objection to the present radiating clavier which appears to have the most weight, is that the distance between any two natural keys varies to an inconvenient extent in the heel and toe direction, it seems desirable that the radius which governs the radiation of the keys should be of a much greater length than eight feet six inches,—the present prevailing standard,—and that the keys should be made slightly thinner at the heel end than where they adjoin the raised ends of the sharp keys. It is also desirable that the keys should be made longer than is usual at the present time, so as to render the touch more equal on the naturals. The late Mr. W. T. Best was a strong advocate for thick and flat-faced keys, and no performer on the Organ had a better right to speak authoritatively on such a subject. He required them to be one inch in thickness; and this dimension should be adopted for the keys at the toe-board end, while they may conveniently be reduced to three quarters of an inch at the heel-board end. We do not advocate the adoption of a shorter radius than eight feet six inches for the arc of con-

cavity, although players with somewhat short legs might find pedal keys set to a smaller radius more easily commanded. It is a question worthy of consideration whether an arc of a circle is the most suitable form for the concavity of the pedal clavier; and whether a curve derived from an ellipse would not be more convenient and comfortable. If the latter curve were adopted, the central portion of the clavier would be nearly flat, while its ends would rise somewhat higher than in the case of a circular disposition. We are strongly of opinion that the elliptical curve would render the keys throughout the clavier much more easily commanded by the natural movements of the legs and feet.

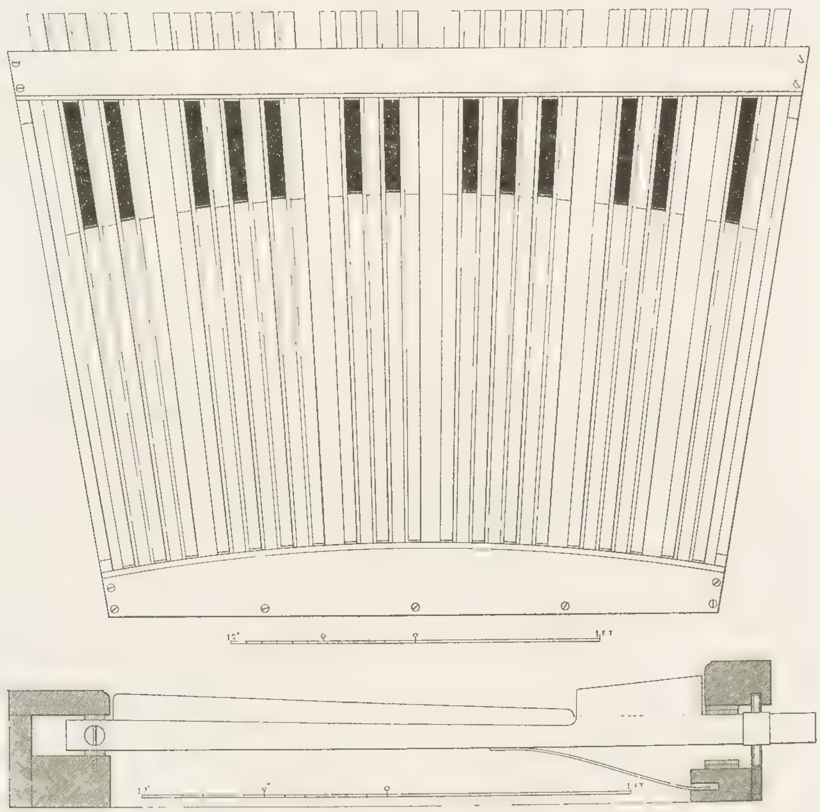


Fig. CIX.

As drawings are more expressive than words in all matters where relative proportions and forms are concerned, we give, in Fig. CIX., the Plan of a radiating

and concave pedal clavier, of the extreme compass of 32 notes=CCC to G, set out to a radius of thirteen feet, and having keys following the lines of radiation, and accordingly thinner by about a quarter of an inch at the heel-board than at the line of the sharps, where they are properly one inch thick. It will be seen, on comparing this Plan with that of the Willis clavier given in Fig. CVIII., that there is considerably more room for the feet to operate in the neighborhood of the heel-board. In the Longitudinal Section are shown the forms of the DD and DD♯ keys, which differ materially from those adopted in all the other pedal claviers in use. It will be observed that the DD♯ key has a considerable inclination which is pleasant to the foot; while the natural key is inclined in the contrary direction, or upward toward the heel-board. Respecting the latter treatment a word may be properly said. Dr. C. W. Pearce, in one of his interesting articles from which we have already quoted, remarks: "The late George Cooper—an organist of no mean reputation—once suggested that the surface of the pedals [the natural keys only] should be constructed with an *upward slope*, so that their outward ends—beneath the organ stool—should be an inch higher than at their entry into the case. This arrangement was stated in the *Musical World* for April 14th, 1855, to wonderfully facilitate the performance of pedal passages requiring an extensive use of the heel. I can find no trace of this suggestion having been discussed—twenty-six years afterwards—at the R. C. O. Conference held in January, 1881." One cannot be surprised at this, seeing that other and more important details were ignored by the few members present at that unlucky "Conference." It is a noteworthy fact that in the single small and very imperfect illustration of pedal keys given in "The Organ," by Hopkins and Rimbault, this slope of the natural key is distinctly indicated. No comment on this treatment is made in the few lines devoted to the pedal clavier in the pages of this long recognized authority on organ-building. It is curious to observe how opinions have differed on the form of the natural keys. It will be seen on reference to the Section of the Roosevelt standard pedal clavier, given in Fig. CVI., that an entirely different treatment obtains: here we find the natural key is highest in the middle and sloped downward toward each end—a treatment which it is not easy to account for, seeing that it cannot be conducive to rapid, comfortable, and accurate pedaling.

That the perfect pedal clavier has yet to be constructed may readily be conceded; and, in the meantime, the ideas of experienced and accomplished performers and organ experts are to be welcomed. But let it be remembered that mere difference of opinion, based on familiarity with this or that form of pedal clavier, is of little value: sound logical arguments must be advanced if proper and satisfactory results are to be attained. There can be only *one perfect pedal clavier*, which, if it is not at present in existence, has yet to be devised. We venture to think that in scheming the long radius pedal clavier, as illustrated in Fig. CIX., we have overcome certain objections advanced against the old Willis clavier, and have placed at the disposal of the organist the most convenient clavier yet constructed.*

*This pedal clavier, designated the "Audsley-Willis pedal clavier," was recently submitted, along with the short radius Willis clavier, to the consideration of a Conference of the American Guild of Organists. The latter form was approved of; but as very few of the members present had any practical knowledge of the pecu-

Judging by the numerous indifferently constructed pedal claviers that one sees, even attached to very expensive and important instruments, one is led to believe that the persons interested in the construction of Organs consider the pedal keys, because they are performed upon by the feet, unworthy of any special care or attention. Such, however, should not be the case. There is no reason why the pedal clavier should receive less careful workmanship than the manual claviers: and when one realizes the great importance of the Pedal Organ, when it is properly appointed tonally, one cannot overrate the importance of having its mechanical appointment as perfect as ingenuity and perfect workmanship can make it. The perfection of a pedal action, whatever its nature may be, should certainly commence with a properly designed and carefully constructed clavier. We think it safe to say that there would be better pedal-players among organists to-day had they given proper consideration to the character of the claviers on which they practiced, and had organ builders thought it proper to expend some careful thought and skill on their form and construction. Perhaps much of this neglect has been due to the fact that in no treatise hitherto published on the Organ has the subject of the pedal clavier received anything approaching proper attention.*

The present Chapter would be obviously incomplete without some allusion to the double pedal claviers introduced in certain Organs constructed by Messrs. E. F. Walcker & Co., of Ludwigsburg. One notable instance of their use is furnished by the Grand Organ in the Cathedral of Ulm. Such double pedal claviers may now be classed among the curiosities of German organ-building, for they are never likely to be used in days to come. From a theoretical point of view they have something to recommend them, but from a practical point of view they are to be condemned. It has been found quite difficult enough to construct a single pedal clavier satisfactory in all respects: to construct two associated claviers in any desirable fashion is an absolute impossibility.

In the accompanying illustration, Fig. CX., is given a Section through the two pedal claviers, showing their positions with respect to each other, and to the

liarities of the radiating and concave clavier, it is just possible that time may show the unwisdom of the selection. Although the Audsley-Willis clavier had been constructed from our drawings, at the request of the officers of the Guild, that distinguished body had not the common courtesy to invite us to attend the Conference. Accordingly, we had no opportunity of stating our views respecting the rival claviers; or of learning the reasons advanced for adoption of the Willis and the rejection of the improved clavier.

* That this statement is not without foundation is proved by the following facts: In "L'Art du Facteur d'Orgues," by Dom Bedos, sixty-eight lines only are devoted to the description of, and remarks on, the pedal clavier. In "Die Theorie und Praxis des Orgelbaues," by Töpfer-Allihn, only about one page is given to the construction of a very imperfect clavier. In "The Organ," by Hopkins and Rimbault, the subject of the pedal clavier is dismissed, so far as its construction is concerned, in a single paragraph of nine lines, illustrated by one small incorrect diagram. In "Organs and Organ-Building," by C. A. Edwards, the pedal clavier is treated at somewhat greater length, thirty-two lines being devoted to it, accompanied by a diagram copied (reversed) from that in the preceding work. In "A Practical Treatise on Organ-Building," by F. E. Robertson, a better state of affairs obtains, for we find about a page and a half devoted to this important clavier, accompanied by a part Plan, Transverse Section, and Longitudinal Section of a Royal College of Organists pedal clavier. In "Organs and Tuning," by Thomas Elliston, the pedal clavier is dismissed in fourteen lines, unaccompanied by any illustration; and in "Organ Construction," by J. W. Hinton, M. A., Mus. Doc., neither a word of description nor a single complete illustration of a pedal clavier of any kind is given, truly a remarkable fact in connection with a work bearing so comprehensive a title.

manual claviers. The illustrations of this double clavier are reproduced from full size drawings kindly furnished by Messrs. Walcker specially for this treatise. The construction of the claviers is characterized by extreme lightness in comparison with that which obtains in English and American pedal claviers; but the playing portions of the keys, which are fastened to the key-bodies, are fully an inch in width, and present a suitable surface to the foot. The forms and proportions of the four different keys are shown in the Plan of the double clavier, Fig. CXI. As usual in German pedal claviers, the compass is CCC to D = 27 notes. The

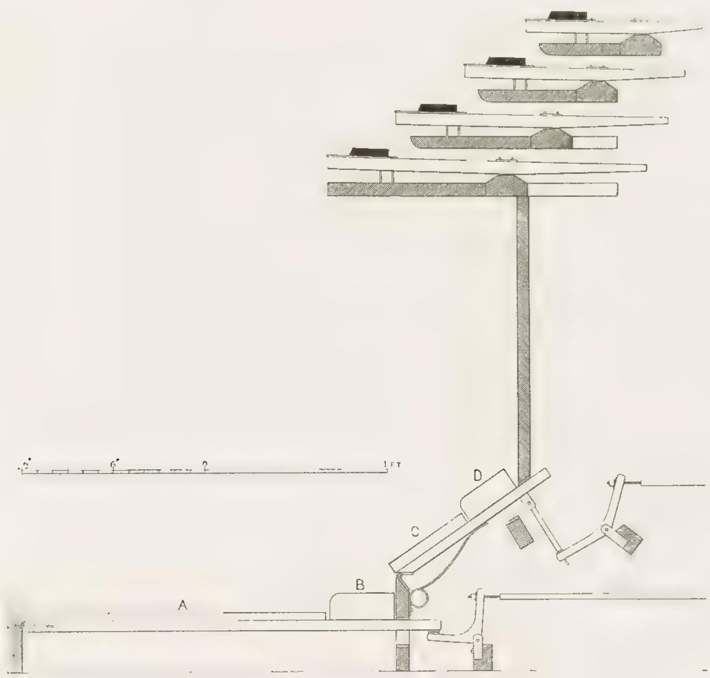


Fig. CX.

distance from center to center of two adjacent natural keys is 2¾ inches, a distance practicable in a twenty-seven note clavier.

Whatever form the pedal clavier may assume, there can be no question as to the desirability of its being properly constructed. There is no reason why it should not be made as carefully as a manual clavier; and we think there is little doubt, as we have already said, that there would, as a rule, be better pedal-players if organ builders, generally, furnished more scientifically formed and more carefully constructed pedal claviers.

The bodies of the pedal keys should be made of some straight-grained hardwood, preferably light in character. The natural keys may be formed of single pieces of wood, as is common in English work; but we recommend the adoption of the method, common in good American work, and as indicated in the Section of the Roosevelt standard pedal keys given in Fig. CVI., of attaching to the upper edge of the bodies special slips of holly or some close-grained and light-colored wood, which, when worn by long use, can be easily renewed without interfering with the pivoting, fitting, or action of the keys. When such special slips are used,

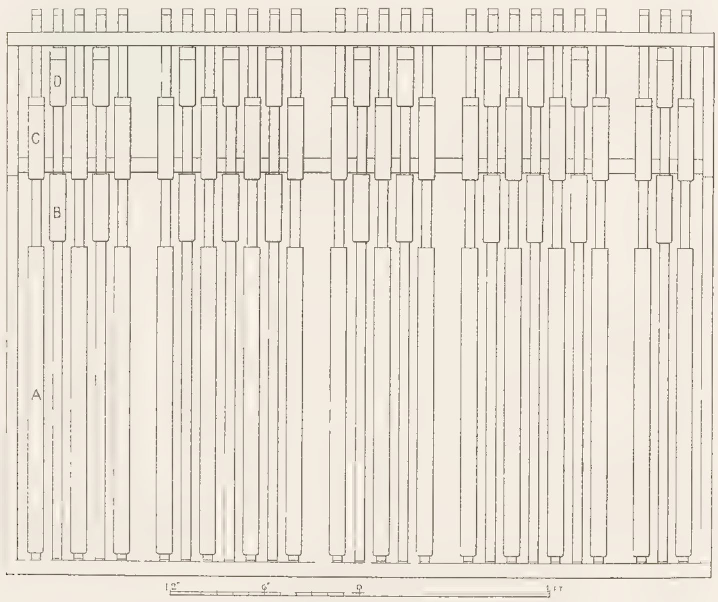


Fig. CXI.

an organist can readily have any shape of playing surface provided for the natural keys that may seem to him most desirable. These slips should extend along the key bodies from the heel-board to the front line of the playing parts of the sharp keys, as in the Roosevelt standard pedal clavier. The playing surfaces of the keys, with or without slips, should be flat in the direction of their width, and be true to the arc of concavity, so that the feet may move over them and press them comfortably in playing. Rounded pedal keys are most objectionable to good players, and should never be made. Flat-surfaced keys were very strongly advocated by the late W. T. Best. He also advocated the adoption of one inch for the width of all playing surfaces. There can be no doubt that thin or narrow pedal keys are to

be condemned. The playing surfaces of the Ulm Organ pedals exceed an inch in width.

The playing portions of the sharp keys should be formed of some dark-colored hardwood, preferably ebony or rosewood, thereby giving to the pedal clavier a handsome appearance. These portions must be attached to the key bodies by glue and screws. The form of the sharps is a matter of considerable importance, yet we find it varying materially in claviers by different makers as if it was simply a matter of taste or appearance. The most objectionable form is that which presents a level or horizontal playing surface extending from a boldly rounded front; yet this is by no means an uncommon treatment; and, strange to say, the inconvenient form is usually met with in conjunction with keys that are objectionably short. The most convenient sharp keys are long in form, with their playing surfaces starting from an almost sharp edge in front and sloping upward, toward the toe-board, at an angle of 6 degrees. This allows the performer's feet to feel the surface of the sharps comfortably, and to heel and toe the adjoining keys when necessary. The adoption of a straight toe-board in the radiating and concave clavier, as shown in Fig. CIX., favors this desirable end, because it allows the lateral sharp keys to be considerably elongated, just where the feet require the greatest assistance. The playing surfaces of the sharp keys should be flat in the direction of their width, and be true to the arc of concavity, corresponding in this respect with the natural keys, as previously described. The fronts of the sharp keys should rise from an inch to an inch and a quarter above the adjacent surfaces of the natural keys, and their upper front corners should only be very slightly rounded, as indicated in the Longitudinal Section in Fig. CIX. When more wood is removed from the fronts, by rounding them considerably, the playing surfaces of the sharp keys are undesirably shortened. The most objectionable outline for these keys is that shown in the Section of the double pedal claviers, Fig. CX.

Next in importance to the proper form and proportion of the pedal keys, are their correct disposition and their accurate fitting. While in flat pedal claviers the keys may be disposed vertically in the key-frame, it is obvious that in concave claviers they should radiate correctly from the arc of concavity, as shown in the Transverse Section in Fig. CVIII. This arrangement is imperative, simply because the feet of the performer, who is properly seated, press the keys in a radial manner and not vertically, save exactly in the center of the clavier. The radial arrangement of the keys also minimizes their friction in the register, and it tends to prevent objectionable noise in rapid playing.

The heel ends of the keys should be pivoted much in the same manner as are the keys of the manual claviers; namely, on strong steel pins driven into the heel-block. The best manner of pivoting is shown in the accompanying illustration, Fig. CXII. The heel end of a natural key is shown at A. Through it is bored the large hole B, so as to enable it to rock freely on the steel pin C. A round hole, closely fitting the pin, is bored from the under side of the key into the hole B; and from the upper side of the key a small slot is cut, likewise into the large hole, which allows the key to rock steadily on its pin. Strips of thick felt are

secured to the heel-block D and the heel-board E. A simpler, but by no means so satisfactory a method is shown in the lower clavier in Fig. CX. This consists of a steel spring, secured in a saw-cut in the end of the pedal key, and fixed to the heel-board of the key-frame. Mr. F. E. Robertson, in "A Practical Treatise on Organ-Building," recommends a somewhat similar but better arrangement, which, as in the Walcker double pedals, serves both as a hinge and a recovering spring. This extremly simple method of attaching and springing the pedal keys is illustrated in Fig. CXII. F is the heel end of a pedal key, to which is firmly screwed the steel spring-plate G. This spring is about 6 inches long and $\frac{1}{16}$ inch thick; its width is dictated by the thickness of the key. The spring is firmly held in position by the

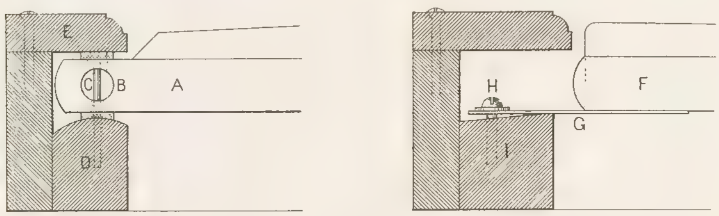


Fig. CXII.

screw H, which also regulates the weight of the key touch by pressing the spring downward on the inclined heel-block I. The mode of springing the pedal keys which are pivoted in the manner previously described is shown in the Section of the Roosevelt standard pedals, Fig. CVI., and in the Section given in Fig. CIX. It consists of a piece of stout steel wire, let into the under side of the pedal key, bent downward, and bearing, at its free end, on the toe-block of the key-frame, or in a hole bored in the face of the same. When carefully regulated, this mode of springing gives a very agreeable touch, preferable, in our opinion, to any other.

The keys must be very accurately fitted in the register under the toe-board; and to prevent noise in action, they should be covered with smooth leather where they pass through the register. Both the leather and the register must be well black-leaded. Thick felt pads must be attached to the upper side of the toe-block and the under side of the toe-board, as indicated in Fig. CIX. In short, every expedient must be adopted to eliminate friction and secure silence in action. For flat pedal claviers, the register is best formed of round beech rods driven into holes in the toe-block, as in the Roosevelt standard claviers: but for radiating and concave claviers, the register should be cut from a beech board about ½ inch thick. The surfaces against which the keys rub must be rounded and carefully finished. The key-frame may be made of oak or any suitable hardwood in all its exposed portions. For the Chamber Organ, the entire pedal clavier should be made of choice woods; the key-frame being of the wood of which the case is constructed, and finished to correspond.

CHAPTER XXII.

THE PEDAL COUPLERS.

—MECHANICAL—

THE Couplers which belong to the Pedal Organ system are of two classes. The first and most important class embraces those couplers which connect the manual divisions of the Organ with the pedal division, or, as is usually the case, those which connect, in a mechanical manner, the manual claviers with the pedal clavier. The second class embraces those which act on the Pedal Organ itself. While both classes are of great value, the former class comprises certain couplers that are indispensable in properly appointed Organs. When the Pedal Organ is large and has its tonal structure complete, there is no necessity to introduce any coupler which acts on itself: but when its tonal appointment is insufficient, or necessarily very limited, the introduction of the Pedal Octave Coupler is to be recommended, especially so when the proper provision is made for its operation throughout the entire compass of the pedal clavier.

Of the couplers connecting the manual claviers to the pedals, those which couple in the unison, or which connect the CC notes of the manuals to the CCC note of the pedals and so on regularly upward, are the ones universally met with in all properly appointed modern Organs. These are designated the Great to Pedal Coupler, Choir to Pedal Coupler, Swell to Pedal Coupler, Solo to Pedal Coupler, etc.; the term *unison* being understood in each case. In certain rare instances other couplers have been introduced: notably in the remarkable Chamber Organ constructed by Mr. H. Wedlake, of London, in 1863, for H. A. Hankey, Esq., where two unusual couplers were inserted; namely, the Swell to Pedal Octave Coupler and Swell to Pedal Super-octave Coupler. An example of the super-octave coupler obtained in the Organ in Trinity College Chapel, Cambridge, where it was uniquely labeled "Canto Fermo Coupler." This coupled the Choir Organ to the Pedal from middle c^1 upward. Messrs. Gray and Davison inserted a Swell

to Pedal Octave Coupler in the Organ constructed by them for the Irvingite Church, Gordon Square, London. This, of course, coupled the Swell Organ to the Pedal from tenor C upward. The value of such special and unusual couplers depends chiefly on the tonal appointments of the Pedal Organ and the manual division or divisions on which they act; and it may also depend on the special purposes for which the Organ is designed. There can be no doubt that in the Concert-room Organ, and in the most complete type of Chamber Organ, the Solo to Pedal Octave Coupler and the Swell to Pedal Octave Coupler would be valuable and productive of many fine orchestral effects; notably the rendering of pronounced melodic or solo passages by the feet, while both hands are engaged in the full accompaniment on the other, uncoupled, claviers. The use of the Swell to Pedal Super-octave Coupler, or the Choir to Pedal Super-octave Coupler, as in the case of the Organ in Trinity College Chapel, Cambridge, would seem to be very circumscribed; so much so that the introduction of such a coupler calls for no serious consideration.

We may now return to the subject of the manual to pedal unison couplers. As we have already remarked, these couplers are universally met with in all properly appointed modern Organs: and, indeed, they are absolutely necessary in the average American and English Organs, which are distinguished, if by anything, by the insufficiency of their Pedal departments. While the manual to pedal unison couplers are valuable when put to a legitimate and artistic use, they are little short of a fraud, and they certainly are a delusion and a snare, when they are introduced with the view of covering the deficiencies in the tonal appointment of a Pedal Organ. In testing the tonal value of an Organ these couplers should not be resorted to.

It is right to remark that in too many cases it is practically impossible, through insufficiency of space, to find accommodation for a properly proportioned Pedal Organ without impoverishing to a very serious extent the manual divisions. Under such circumstances, couplers, or what are equivalent to couplers, adding certain suitable manual stops to the Pedal Organ are extremely valuable. To be able to command an expressive stop of 16 ft. pitch (such as a BOURDON, 16 FT., in the Swell Organ) from the pedals, without having to do so through the agency of the general unison coupler,* is a matter of the utmost value; for the unexpressive character of the Pedal Organ is a serious and remarkable shortcoming in the Organs of to-day. When this expedient is resorted to, it must not be disguised so as to mislead the inexperienced. The coupler should be labeled, for instance, Swell BOURDON, 16 FT., to Pedal, with or without the addition of the word Coupler. Such an expedient may, perhaps, be considered "borrowing;" but it is no more borrowing than when the general Swell to Pedal Coupler is in operation, connecting all the stops in the Swell Organ with the Pedal.

We now come to the consideration of the second class of pedal couplers, or

* Seeing that the coupler here alluded to connects the unison notes of a manual division to the unison notes of the Pedal Organ, no exception can well be taken to the term *unison coupler;* although the manual to pedal coupler is strictly an *octave coupler* inasmuch as it connects a clavier whose unison tone is of 8 feet pitch to one whose unison tone is of 16 feet pitch.

those which act on the Pedal Organ itself. These are the Pedal Octave Coupler and the Pedal Super-octave Coupler; both requiring, for their proper effect, the stops of the Pedal Organ to be carried up beyond the compass of the clavier; for the former coupler, one octave, and for the latter coupler, two octaves. As the additional pipes, even in stops of 32 feet pitch, are neither large nor expensive there are no serious objections to their introduction. The value and general utility of a small Pedal Organ are considerably increased by the judicious use of the two couplers under consideration.

The objections that have been advanced against the introduction of the manual octave coupler operating on its own clavier, do not obtain, to any appreciable extent, in the case of the Pedal Octave and Super-octave Couplers. This is so, because it is very seldom that more than a single pedal key is put down at one time; and because, owing to the grave character of the pedal notes, the balance of tone is not seriously interfered with by the addition, to the true unison tone, of the octave and super-octave tones in the same stops. We may remark that in scaling, voicing, and regulating the pipes of the added octaves, care should be taken to graduate the strength of their voices as they ascend, so as to prevent their impairing the due predominance of the true unison pitch of the department.

Under the conditions which at present obtain in modern instruments, in which the Pedal Organ consists of a single tonal department, the octave and super-octave couplers are practically useless so far as the creation of different *timbres* or tonal colorings are concerned. This is so, because they merely operate upon the same stop or stops from which the fundamental or unison tone is derived. This fact should not be lost sight of in scheming the tonal appointment of an Organ.

We have elsewhere strongly advocated the division of the Pedal Organ into two sections of different tonal character, one of which is to be expressive; and, when this system is adopted, the octave and super-octave couplers should certainly be made to link the expressive section to the unexpressive one. Under such an arrangement, the couplers would become important agents in the production of different *timbres* and compound tones. When the Pedal Organ is divided, as above mentioned, a Pedal Unison Coupler would also be required to combine the voices of both sections in the unison. With a properly appointed Pedal Organ, divided, and furnished with the three couplers in the manner suggested, an absolutely inexhaustible variety of tonal effects could be produced, altogether independent of aid from the manual stops.

In the foregoing remarks we have not mentioned a sub coupler operating directly on the Pedal Organ, because unless some one or more of the unison stops be carried down to CCCC, or the 32 ft. note, such a coupler would be an absurdity. The sub coupler would certainly be a legitimate and very useful accessory in a Pedal Organ which contains no complete and special open stop of 32 ft. pitch, but where such a stop as the unison BOURDON has the CCCC octave added to it. This expedient would not entail a serious expenditure, and should be adopted when there is space sufficient for the accommodation of the twelve additional pipes. We consider such an arrangement preferable to the introduction of the QUINT, $10\frac{2}{3}$ FT., for the production of the so called "acoustic bass."

We may now consider the construction and forms of the purely mechanical couplers which unite the manual claviers to the pedal clavier. In Organs of small or moderate dimensions, the usual and most convenient form of the manual to pedal unison coupler comprises a roller-board, short trackers and pull-down wires, a set of backfalls, stickers, and a sticker register. The roller-board is required to conduct the pull-down motion from the wide stretch of the pedal keys to directly under the thirty lower keys of the manual. Each roller is furnished with two arms, one of which is placed directly over a pedal key, and the other directly under the corresponding manual key. Both arms project from the roller in the same direction, so as to secure a similar motion. The pedal arm is connected to the pedal key by a short tracker or pull-down wire. Between the manual arm and the manual key above is placed a backfall—connected to the said arm by a pull-down—which conveys the motion to the tail of the manual key, converting it from a pulling to a pushing motion. A sticker rises from the backfall, passes through a register and bears (when in action) against the under side of the tail of the manual key. This simple mechanical action will be clearly understood from

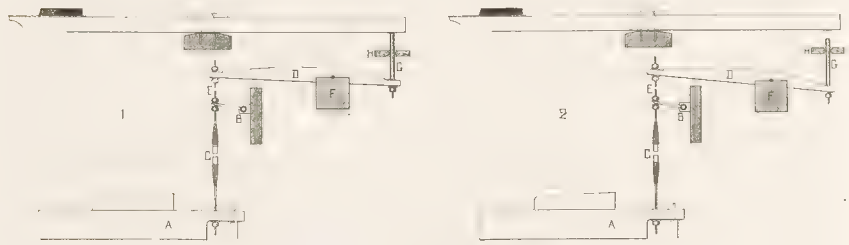


Fig. CXIII.

the accompanying illustration, Fig. CXIII. In Diagram 1 the coupler is shown on touch or in action. A is the end of the pedal key, which is connected to one arm of the horizontal roller B by the pull-down tracker C. D is the backfall, which is connected to the other arm of the roller by the pull-down wire E, and which is pivoted on the backfall beam F. G is the sticker, rising from the backfall, passing through the register H, and bearing (as indicated in Diagram 1) against the tail of the manual key I, which is buffed to prevent noise. By this simple mechanical arrangement motion is conveyed from the pedal key to the manual key; for when the pedal key is put down the sticker G raises the tail of the manual key, and moves the key action connected therewith. In Diagram 2 the coupler is shown out of action. This release is accomplished by simply lowering to a small extent the backfall beam F. The sticker G cannot now reach the tail of the manual key when raised by the pedal motion. As the touch of the pedal key is much deeper than that of the manual key, the pivot of the backfall has to be sufficiently removed from the center to obtain the correct adjustment. Any simple and convenient mechanical device may be adopted to raise and lower the backfall beam.

When two manual claviers have to be coupled to the pedal keys, in the manner above described, it is only necessary to introduce a second backfall frame and set of stickers; the front ends of the backfalls being connected to the single set of pull-down wires. The arrangement is shown in Fig. CXIV. A is the backfall belonging to the Great Organ key B, and C is the backfall belonging to the Swell Organ key D. The short sticker E passes through a register and bears lightly against the buffing on the underside of the Great key; while the longer sticker F also passes through a register and bears against the buffing on the tail of the Swell key D. Both the backfalls are actuated by the same pull-down wire G, which holds their front ends, as indicated. The stickers, in this case, being kept

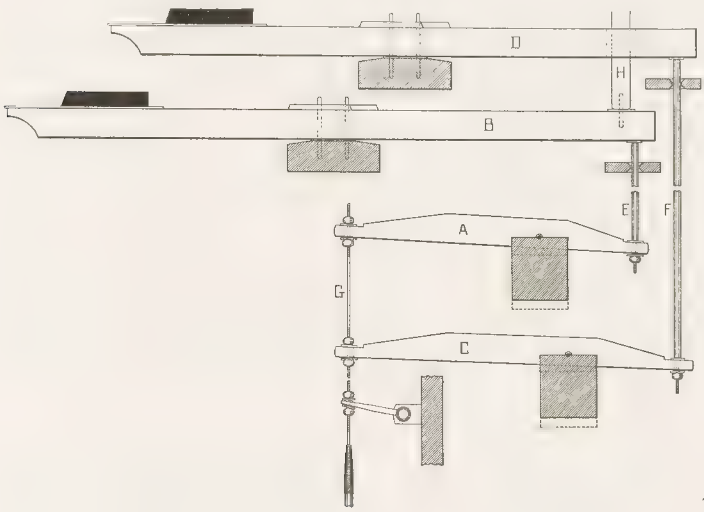


FIG. CXIV.

in position by their registers, are in no way connected with the tails of the keys; and, accordingly, the keys can be removed without throwing the stickers out of position. H is the flat sticker belonging to the Great Organ key action, passing through a mortise cut in the Swell key. The registers are sometimes omitted; and the stickers have phosphor-bronze or plated pins inserted in their upper ends which pass into holes in the tails of the keys. These pins are made long enough to allow the coupler to be put out of action without their being withdrawn from the holes in the keys. This arrangement does not favor the easy removal of the keys. When the key action is connected directly with the key tails by backfalls or squares, the pins of the coupling stickers are sometimes inserted in holes in their front ends close to the tails of the keys, as shown in the accompanying diagram,

Fig. CXV. A is the tail of the Great Organ key, into which the coupling sticker B is pinned. C is the tail of the Swell Organ key, fitted to receive the rounded end of the backfall or square D. The Swell to Pedal coupling sticker E is here pinned into the backfall or square, bearing directly on the key action. The manner

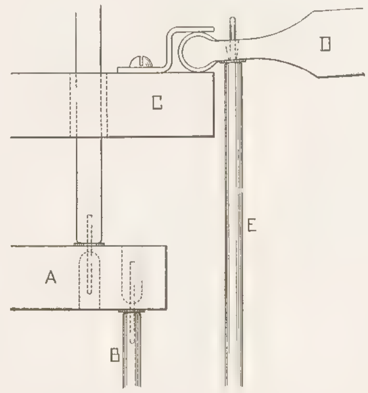


FIG. CXV.

in which the action is connected with the key secures its desirable participation in the motion imparted by the pedal coupler. Further remarks on this subject will be found in the Chapter on the Manual Couplers.

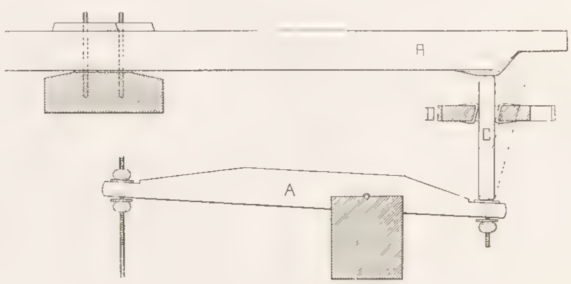


FIG. CXVI.

Couplers, similar in general construction to those above described, are sometimes put in and out of action by moving their sticker registers instead of their backfall beams; and when the key action and manual couplers admit of this treatment, and proper means are provided for putting the couplers on touch while the

pedals are being played, all will be found perfectly satisfactory. The general principle of this treatment is shown in Fig. CXVI. A is the coupling backfall, and B is the tail of the manual key on which the coupler acts. C is a flat sticker, about 3/8 inch broad by 1/4 inch thick, slightly rounded at its upper end so as to glide easily on the sloped buffing of the key tail, which, along with the top of the sticker, is well black-leaded. The lower end of the sticker is also rounded so as to rock

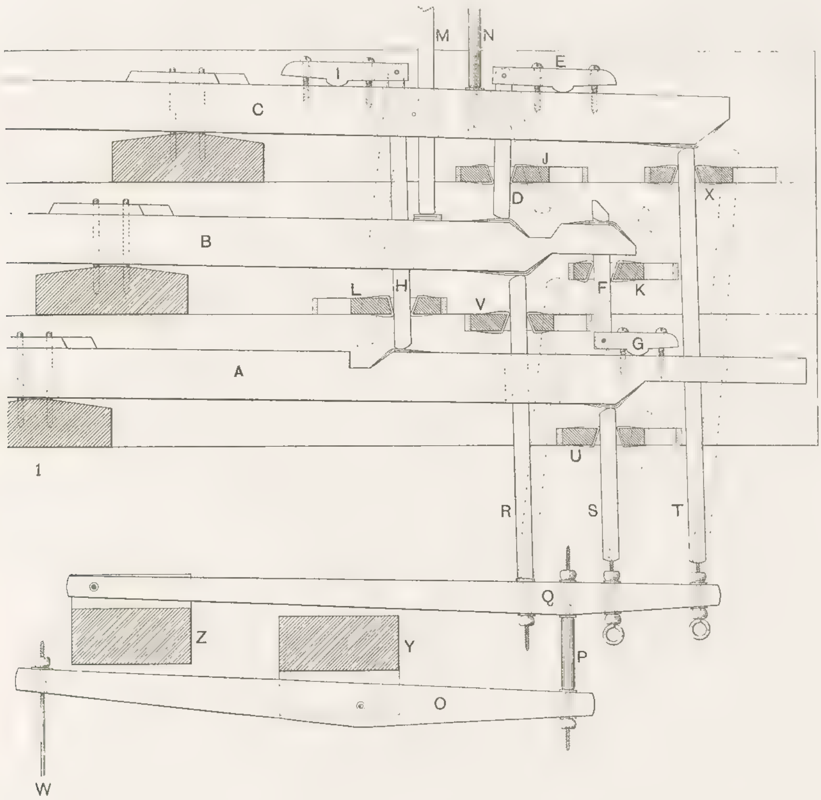


Fig. CXVII.

smoothly on the end of the backfall, to which it is secured by a tapped-wire and button. The register D, through which the sticker passes easily, and by which it is held in position while on and off touch, moves backward and forward in openings cut through the cheeks of the key-frame, as indicated by the prolonged lines. When the sticker is deflected, as shown by the dotted outline, it can be moved upward by the operation of the pedal key without coming in contact with the tail of the key B. The most complete development of this coupling action is that which obtains

in the Roosevelt standard system of mechanical coupling, shown in the accompanying illustration, Fig. CXVII. W is the pull-down wire connected with an arm of a roller below. This actuates the backfall O, which, in turn, moves the lever Q through the agency of the short sticker P. The backfall and lever are held in position by, and pivoted on, the stationary beams Y, Z. From the lever Q rise the three flat stickers R, S, T, two of which are adjustable by means of their tapped-wires and buttons. The sticker R is adjusted to touch by the button on the pull-down wire W. The sticker R passes through a mortise in the lower key A, then through the movable register V, and bears against the buffing on the underside of the middle key B. When this sticker takes the position indicated by the dotted outline, having been moved by the backward motion of the register V, it can no longer affect the key B. The adjustable sticker S simply passes through the movable register U, and bears against the buffing of the lower key A. Its dotted outline shows its position when out of touch with the key. The long adjustable sticker T passes through the tail of the lower key, then through its movable register X, and bears against the buffing at the end of the upper key C. Its dotted outline indicates its position when moved out of touch by the register. It will be observed in this arrangement of manual to pedal couplers that only one stationary backfall frame is connected with the pedal roller-board, and that only one supplementary set of levers is required to carry the three sets of stickers. These levers, being long and pivoted at the extreme end, equalize to the requisite extent the upward push of the different sets of stickers, aided by their positions with respect to the tails of the keys on which they act. Care has to be taken, in all such mechanical manual to pedal couplers as have been described, to so adjust the action as to move the manual keys to exactly the same extent as they are moved by the fingers in the course of ordinary playing. Under no conditions must the couplers lift the keys from their bearings on the mid-rails; and it is equally undesirable that there should be any lost action in the couplers. Such lost action would greatly interfere with artistic and delicate pedal-playing, so desirable in the rendition of chamber organ music of an orchestral character. There are several advantages attending the system adopted in the Roosevelt standard claviers; notably in dispensing with two backfall frames, and in having the single one that is introduced a fixture. The action required to move the sticker registers backward and forward is much lighter than that required to lift the heavy backfall frames and their series of stickers, unless they are properly balanced.

In detached and reversed consoles, such as those of many modern French Organs, in which all the trackers from the manual claviers are carried downward to the squares connected with the trackers which pass horizontally under the platform on which the performer is seated, the backfalls of the manual to pedal couplers do not act directly on the tails of the keys, but on the trackers which descend from them. The backfalls, which are pivoted on movable beams, and have their front ends attached to the pull-down wires, in the manner shown in Fig. CXIV., act upon studs, projecting blocks, or buttons on the vertical trackers, lifting them, and allowing the playing ends of the manual keys to drop of their own weight. In the Grand Organ in the Church of Saint-Sulpice, at Paris, in which the claviers are

neither detached nor reversed, the descending trackers from the second, third, and fourth claviers are operated on by the three corresponding sets of coupling backfalls, in the manner just described; while the tails of the keys of the first clavier are pushed up by stickers on the rear ends of the associated backfalls; and the backfalls which rest on the key tails, and operate the pneumatic levers of the division, are also actuated. In all cases the couplers are put out of touch by lowering their backfall beams.

When a manual to pedal octave coupler is introduced, in conjunction with the roller-board and backfall action, a set of oblique backfalls is required to convey the motion from the unison pull-down wires to the tails of the manual keys an

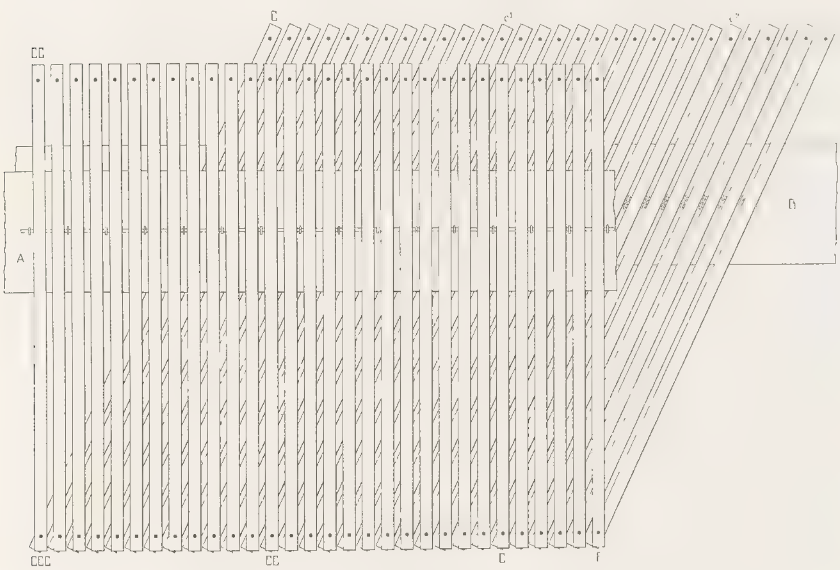


Fig. CXVIII.

octave higher. Accordingly, the back ends of the oblique backfalls will have to extend slightly beyond those of the straight or unison backfalls, to admit of the double stickers required under the tails of the manual keys from tenor C to f¹. Below and above these notes only single stickers are required. The manner in which the unison and octave sets of backfalls are associated is shown, in plan, in Fig. CXVIII. The unison set of backfalls, carried on the beam A, is located above the octave set which is carried on the beam B. The ends of these beams are supposed to be continued farther than shown, so as to join the levers that support and move them. The small black dots on the front ends of the backfalls represent the pull-down wires which are attached to the arms of the rollers below;

these wires pass through both the sets of backfalls. The small black dots on the rear ends of both sets of backfalls represent the holes for the reception of the round stickers which extend to the tails of the manual keys above. It will be observed that two complete rows of stickers are required, so as to secure the independence of the two couplers. The couplers overlap from C to f^1, and, accordingly two sets of stickers are necessary for the manual keys throughout this portion of the clavier. As the stickers have only a vertical motion they all pass through one register. Both the couplers act independently of each other, being controlled by the raising and lowering of their respective backfall beams A and B.

The roller-board for the manual to pedal couplers is formed of a piece of straight-grained bay-wood, about $\frac{3}{4}$ inch thick, and of sufficient length and width to receive the thirty rollers and their studs. To prevent its warping, the piece should have two or three strong bars glued and screwed across its back surface. The rollers are formed of drawn iron tubing, $\frac{7}{16}$ inch diameter, having their ends plugged to receive the plated or phosphor-bronze pivot pins. Each roller is furnished with two iron arms, bushed with leather, and riveted into holes drilled to receive them. The rollers are carried by studs of hardwood bushed with cloth, or of brass bushed with leather. The rollers are placed as close to each other as possible without any liability of touching; and are arranged so as to carry the motion from the pedal keys to the backfalls under the manual keys in the most direct manner, and with the view of securing the minimum depth of board. The arrangement of the rollers of different lengths varies in accordance with the respective positions of the pedal and manual claviers, as the action to and from the rollers must in all cases be vertical or as nearly so as practicable. In the accompanying illustration, Fig. CXIX., is given a drawing of a coupler roller-board, showing its relation to the pedal and manual claviers, its trackers to the pedal keys, and its pull-downs to the coupler backfalls under the manual keys. The ends of the pedal keys, to which the lower ends of the trackers are attached, are indicated at A. The trackers B have their upper ends connected, by means of tapped-wires and buttons, to the bushed arms of the horizontal rollers D. From the other arms of the rollers rise the pull-downs E, having their upper ends connected with the front ends of the coupler backfalls F and G, as indicated. The front ends of the manual keys are shown at H. When two or more sets of backfalls are introduced, all except the upper set should have their front ends split with a saw, in the vertical direction, so as to allow the pull-down wires to be passed into their holes without necessitating the removal of the several buttons and cloth washers. The upper backfalls, which are not split, hold the pull-down wires in their proper position. The trackers B must be made sufficiently rigid in themselves, and must be so attached to the pedal keys, as to act as stickers when the keys are allowed to rise after having been put down by the feet. This is necessary to prevent any sluggish motion in the stickers at the tails of the manual keys, or at the ends of the backfalls where they come in contact with the descending key action, as in the mechanism of the detached and reversed console. For the sake of distinctness, the rollers, for the most part, are shown in Fig. CXIX. wider apart than is necessary in actual work.

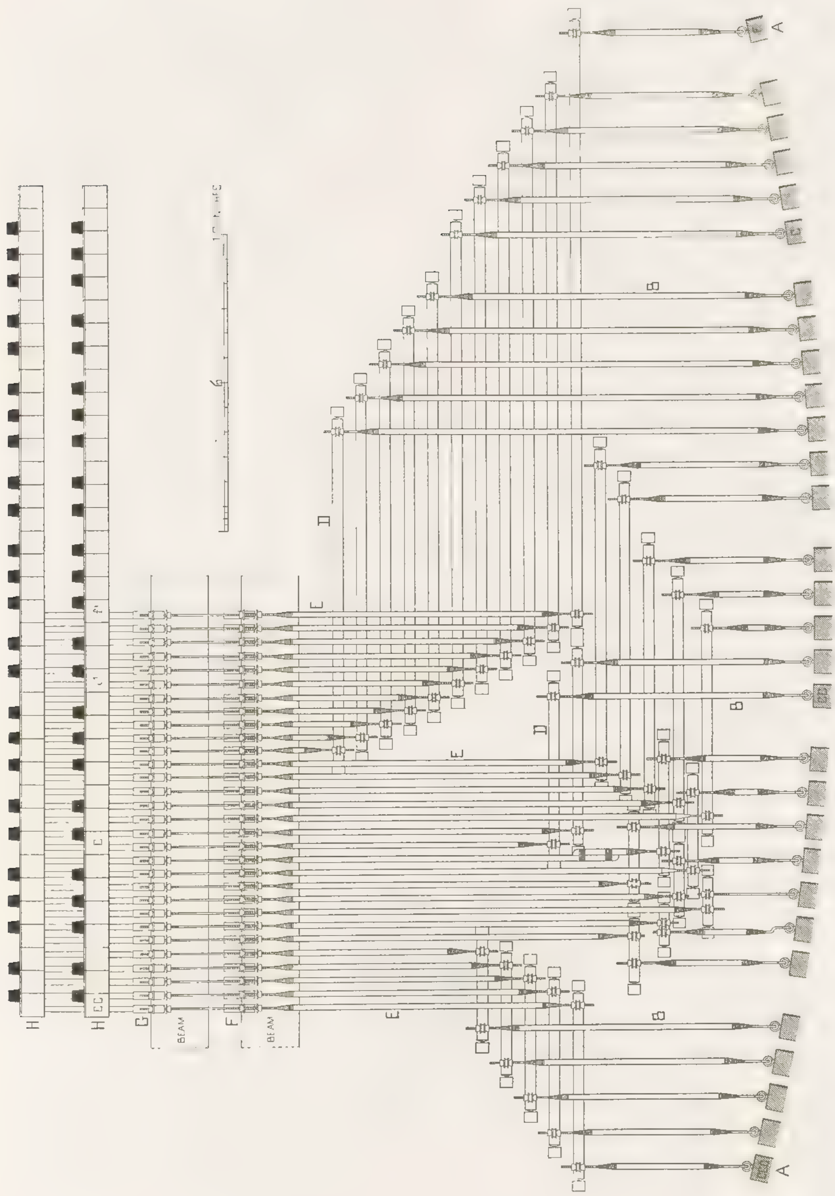


Fig. CXIX.

Before concluding the present Chapter it is desirable to consider a matter of some importance that has not been touched upon in the preceding pages. In the ordinary mechanical manual to pedal couplers, introduced in instruments having only two manual divisions—Great and Swell—and a poorly appointed Pedal Organ, it is extremely rare to meet with any arrangement to impart independence to the Great to Pedal Unison Coupler—that is, to enable the Great to be coupled to the Pedal Organ without involving the Swell Organ, while the Swell to Great Unison Coupler (situated between the claviers) is drawn. The advantage of having such an independent Great to Pedal Coupler must be obvious to every one who has had any experience with two-manual Organs. By its introduction a much greater variety of tonal effects are placed at the disposal of the performer. While it may be desirable to have the Swell coupled to the Great, it is not always desirable to have both these divisions coupled to the Pedal Organ. While the manuals are coupled together it is always possible to couple the Swell to the Pedal Organ without affecting the Great Organ ; and it should be equally possible, under the same conditions, to couple the Great to the Pedal Organ without operating on the Swell keys through the agency of the Swell to Great Coupler. To secure the independence of the Great to Pedal Coupler it is only necessary to connect the coupler to the key action instead of to the keys, providing the action does not compel the Great keys to move along with it. In our opinion, no two-manual Organ should be constructed without perfect independence in all its couplers ; and we are sure every organist will agree with us in this opinion. The only drawback to the action just recommended lies in the fact that the independent Great to Pedal Coupler operates without imparting any motion to the Great keys while the Swell keys are coupled to them by any form of coupler, located between the claviers.

Enough has been said and illustrated to clearly explain the ordinary methods and general principles on which the purely mechanical manual to pedal couplers are constructed and arranged.

CHAPTER XXIII.

THE TRACKER ACTION.

THE term "Tracker Action" is commonly used to designate the purely mechanical action, formed of trackers, stickers, levers, rollers, etc., which connects the manual and pedal claviers with the valves or pallets of the wind-chests of the Organ; by means of which, on the depression of the keys by the hands or feet of the performer, the pipe-work is made to speak.

In the works of the old organ builders the tracker action was the only one used, and, indeed, the only one known. In the great treatise by Dom Bedos, published about one hundred and thirty years ago, the tracker action is alone described and illustrated. A remarkably fine perspective view of the interior of a large Organ, showing the complete tracker action, is given in Plate L. of his Work. The tracker action remained in its primitive or simple state until the introduction of the pneumatic lever, in a practical form, in the year 1841.* This introduction materially modified the action and lightened the touch of the Organ, rendering the coupling of the manuals possible without adding to the weight of the key touch. The old tracker actions were somewhat clumsy and sluggish affairs, requiring a considerable pressure on the claviers; and it was only when modern ingenuity and mechanical skill were brought to bear on their construction that they became at all satisfactory. Immediately prior to the invention of the pneumatic lever, the most perfect tracker actions were to be found in English Organs; and it is a noteworthy fact that nearly all the great strides made in the mechanical branch of organ-building have been due to English ingenuity and skill. The relieving pallet, the pneumatic lever, the tubular-pneumatic action, and the electro-pneumatic action, have all been introduced by English organ builders: and the compound horizontal bellows and the swell-box are also English inventions.

* See Chapter on the Pneumatic Lever.

Until a comparatively recent date the primitive tracker action was to be found in even the more important Organs in Germany, Switzerland, and Holland; indeed, not having heard to the contrary, we believe it still remains in numerous large Organs, including those at Weingarten and Haarlem.

Under the most favorable conditions, the simple tracker action is only suitable for small Organs: for them, however, it is, when properly made and accurately adjusted, the best of all actions. Remarks on this subject are made in the Chapter on the Church Organ, to which we may direct the reader's attention.

Before considering the tracker action in its complete form, it is desirable to describe in detail its component parts; namely, the trackers, stickers, backfalls, squares, and rollers.

The *trackers* are those parts of an action which are invariably employed where a *pulling* motion obtains. They are slender strips or rods of some light, straight-grained wood, preferably clear white pine, oblong, round, or square in transverse section. When oblong they are about $\frac{3}{8}$ inch in width by $\frac{1}{8}$ inch in thickness, or $\frac{5}{16}$ inch in width by $\frac{3}{32}$ inch in thickness; and when round or square they are usually about $\frac{1}{4}$ inch in diameter. The oblong strips are properly used in vertical positions; while the round or square trackers are best adapted for horizontal and oblique positions. Trackers vary in length from a few inches to several feet; and in very long actions two or more lengths are linked together and properly held in position. Flat trackers are readily made by being separated with a cutting-gauge from the edge of a white pine board, previously dressed to the standard thickness; their edges being subsequently shaved with a plane to the exact width required: or they may be cut with a fine circular saw from the edge of a plank, dressed to the required width, their sides having a shaving planed from them so as to remove the marks of the saw and leave them the standard thickness. Simple means have sometimes been devised to obtain perfect uniformity in this final planing. Square trackers are made in a similar manner with the cutting-gauge, the edge of the board ($\frac{1}{4}$ inch thick) being planed true after each tracker is cut off, and the tracker finished with the plane where left rough from the gauge. Round trackers are formed from a board $\frac{1}{4}$ inch thick, by running a $\frac{1}{4}$ inch beading-plane along its edge on each side. The tracker if properly separated from the board may be finished with glass-paper or by being drawn through a cutting hole in a steel plate.

When a tracker has been cut to the proper length to occupy its place in the action, it has its ends provided with a ready means of attaching it to the other parts of the action. Both ends may have wire hooks or tapped-wires secured to them; or, as is very frequently the case, one end may have a hook and the other end a tapped-wire, the latter permitting adjustment in the action. The mode of securing the hook, which is properly made of pliable copper wire, to the end of a flat tracker is shown in Fig. CXX. Diagram 1 is a section through the tracker A, showing the manner in which its end is splayed on one side, and the copper wire B is first bent and passed through the two holes bored in it. Diagram 2 shows the completed hook, firmly locked in the tracker and bent over its splayed end. Diagram 3 is a front view of the finished end of the tracker, showing the position

of the wire hook. The copper wire used for the hook must be of sufficient thickness to withstand the strain upon it without altering its form.

In Fig. CXXI. is illustrated the most workmanlike method of attaching a tapped-wire to the end of a flat tracker. The end of the tracker is splayed on both sides and edges, in the manner shown in the diagrams; and a hole is bored through the tracker at about 1½ inches from its point, and a groove is cut from it to the point, for the reception of the bent end and plain portion of the tapped-wire, as indicated. The tapped-wire B is securely fixed by the end of the tracker A being tightly whipped with colored linen thread, as indicated in the diagrams. It may be mentioned here that for the sake of easy distinction differently colored thread should be used for the trackers belonging to the different divisions of the Organ. When the whipping is finished, it should be securely fixed by being

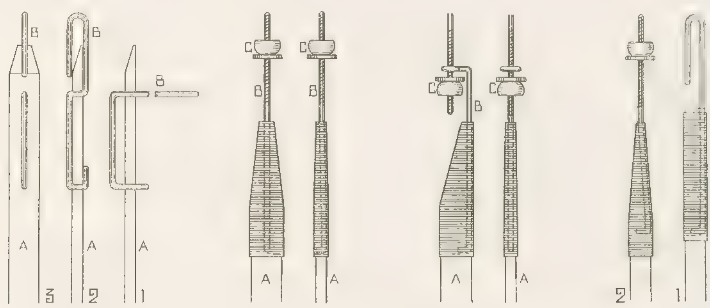


Fig. CXX. Fig. CXXI. Fig. CXXII. Fig. CXXIII.

thoroughly saturated with shellac varnish. When the tracker has to be linked to a tapped-wire attached to some other part of the action, it should have a brass or bronze wire, with a bent ring or eye at its end for the reception of the tapped-wire, fixed to the tracker in the manner shown in Fig. CXXII. The wire B is bedded in a groove cut in the edge of the splayed end of the tracker A, so as to bring the eye practically over the center of the tracker. The end of the tracker is whipped with colored linen thread in the manner already mentioned. Tapped-wires should be made of hard brass or phosphor-bronze, having a clean bold thread cut on them for the reception of the sole-leather nuts or "buttons," shown at C in Figs. CXXI. and CXXII. Aluminium bronze is also a highly suitable alloy for tapped-wires and other parts of the action, and its use is to be strongly recommended; it is strong and very durable. In Fig. CXXIII. are shown the ways in which wire hooks and tapped-wires are attached to the ends of square and round trackers. Diagram 1 shows how the hook is fixed by being let into a hole and groove on one side of the tracker, and then securely whipped to it by colored linen thread. The hook is so bent as to bring its bearing on the center line of the tracker. Matters of this kind are of importance in a properly constructed action. In Diagram 2 the

best manner of adjusting and attaching the tapped-wire to the tracker is illustrated. In this case, the end of the square or round tracker is cut almost to a sharp point, and the tapped-wire is let into a hole and groove on one of its sides and whipped to it by linen thread, as indicated. The exposed part of the wire is then bent true to the axis of the tracker, so that the pull may be direct. Before the trackers are inserted in the action of the Organ they should be covered all over with two coats of thin shellac varnish, and smoothed with fine glass-paper where they are subjected to any friction. They should be black-leaded where they pass through registers, so as to prevent any dragging or tendency to stick. Too much care cannot be taken in eliminating friction in the tracker action.

The *stickers* are those parts of an action which are employed to convey a *pushing* motion between two points in an action that are located a short distance apart. While the above-described trackers can, with their *pulling* motion, be carried to a considerable length, the stickers, which are liable to bend or spring under a sudden *push*, cannot well be made beyond ten or twelve inches in length. When required of a length liable to spring or bend they must be made to pass through a register, at the risk of impairing the touch by friction. Stickers may be made of light bay-wood or straight-grained white pine or spruce. Bay-wood is to be preferred for slender stickers. Stickers may be made round, square, or oblong, in transverse section. When round or square, they are usually about $\frac{5}{16}$ inch in diameter; and when oblong they may be about $\frac{3}{8}$ inch in width by $\frac{7}{32}$ inch in thickness. Oblong stickers invariably require a register to hold them in proper position: when no register is necessary round stickers are to be preferred. A sticker is held in position in an action by passing through a register at one end, and having a wire fixed at the other; or by having a plain pin or a tapped-wire at each end, or a plain pin at one end and a tapped-wire at the other, as circumstances direct. When a sticker is placed horizontally it usually requires two tapped-wires and leather buttons to retain it in position: it is rarely necessary to have a tapped-wire at both ends when the sticker is placed vertically.

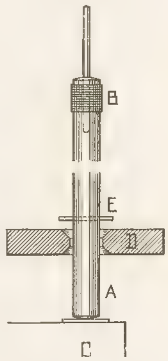


FIG CXXIV.

Stickers that rest against the tails of manual keys (a very common position) need only have rounded bottom ends, being held in position, a short distance above the key tails, by a horizontal register, and kept from falling, when the keys are removed, by small wire pins driven through them just above the register. As the ends of the stickers always bear against the opposing surfaces of the action, it is desirable to make them slightly convex. In Fig. CXXIV. are shown the two ends of a manual key sticker, A and B. The lower end rests upon a piece of leather glued to the key tail C, after passing through the register D, the hole in which is countersunk on both sides, as shown, to reduce the friction to a minimum. The small metal pin E prevents the sticker dropping through the register when the key may be removed. The upper end of the sticker B has a bronze pin driven into its center; and, to prevent any chance of splitting, it is whipped with colored linen thread, as

indicated. Instead of a plain pin a tapped-wire may be screwed into the sticker when it is desirable to use a leather button. All stickers should be protected from the action of damp air by being well covered with shellac varnish.

Before entering on the consideration of those parts of the tracker action which assume the form of levers, it may be desirable to describe and illustrate the different kinds of levers which are employed in organ-building. Levers of the first, second, and third orders, bent levers, and compound levers, are all met with in the mechanical actions of Organs, and, indeed, in some form or other, in organ actions of all kinds.

The lever of the first order is that in which the fulcrum is between the power and the weight or load; and this is the kind most commonly used in the tracker action, and is represented in the manual keys of the Organ as they are now usually made. This order of lever is shown in the five diagrams in Fig. CXXV. In all these the fulcrum, F, is between the power, P, and the load or weight, W.

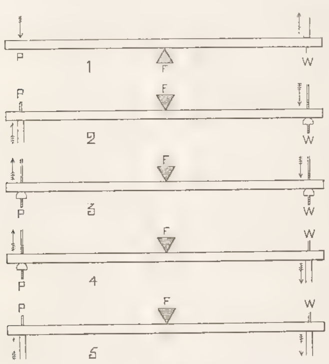


Fig. CXXV.

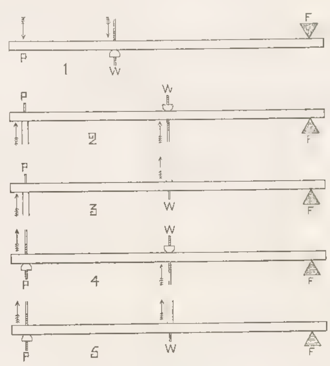


Fig. CXXVI.

The fulcrum is shown in all midway between the power and weight, but it can be placed in any position according to the demands of the action, or when the ends of the lever are required to move over unequal arcs. Diagram 1 represents a manual key; the finger applies the power at P, while the sticker lifts the weight of the action at W. The fulcrum is placed under the lever at F. Diagram 2 shows the lever pushed up at P, and the action pulled down at W, while the fulcrum is placed above the lever; Diagram 3 shows the lever pulled up at P, and the action pulled down at W; Diagram 4 shows the lever pulled up at P, and the action pushed down at W; and Diagram 5 shows the lever pushed up at P, and the action pushed down at W.

The lever of the second order is that in which the weight or load is between the fulcrum and the power. This order of lever is illustrated by the five diagrams in Fig. CXXVI. Diagram 1 is the form of lever employed in many of the old

manual claviers, as illustrated by Dom Bedos (in Plates XLII. and XLIII. of his "Facteur d'Orgues"): here the finger presses down the key at P, while the action is pulled down at W; the fulcrum is above the key tail at F. Diagram 2 shows the lever pushed up at P, and the action pulled up at W; the fulcrum is, of course, placed under the lever at F. Diagram 3 shows the lever pushed up at P, and the action pushed up at W; Diagram 4 shows the lever pulled up at P, and the action pulled up at W; and Diagram 5 shows the lever pulled up at P, and the action pushed up at W; the fulcrum being in these cases under the end of the lever, as indicated.

The lever of the third order is that in which the power is brought to bear between the fulcrum and the weight or load. This form of lever is seldom used in organ-building; although it may be effectively employed when the *power* is ample and the *weight* has to be moved quickly through a more than ordinary distance.

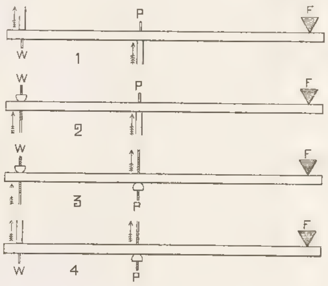


Fig. CXXVII.

This order of lever is illustrated by the four diagrams in Fig. CXXVII. Diagram 1 shows the lever pushed at P, and the action pushed up at W; Diagram 2 shows the lever pushed up at P, and the weight or action pulled up at W; Diagram 3 shows the lever pulled up at P, and the action pulled up at W; and Diagram 4 shows the lever pulled up at P, and the action pushed up at W; the fulcrums being in all cases above the ends of the levers.

In all the forms of lever above illustrated the relative distances of the points of load and power from the fulcrum may be varied according to the nature and demands of the action; but on this self-evident fact it is unnecessary to enlarge. It may also be remarked that in all the levers shown in the diagrams, save those, perhaps, which represent the manual keys of the Organ, the direction of the power and load may be reversed, it only being necessary to place the fulcrum, in each case, on the opposite surface of the lever to that shown.

Bent levers are employed in organ-building for the purpose of carrying a mechanical action in any desired direction; or for immediately altering the direction of any movement; namely, from the vertical to the horizontal, or *vice versa;* or from the vertical, or the horizontal, to the oblique, at any desired angle. The

several diagrams given in Fig. CXXVIII. indicate the more common forms in which the bent lever is used in the mechanism of the Organ. Diagrams 1, 2, 3, and 4 show levers bent at a right angle, the fulcrum, F, being at the point where the arms join. In each case the power is indicated at P, and the load or weight at W; and, as in all the preceding diagrams, the directions of the push and pull are indicated by arrows. Bent levers of this kind are, as will be seen farther on, largely used in the tracker action. Diagrams 5 and 6 are levers bent at an acute angle; and Diagrams 7 and 8 are those bent at an obtuse angle: these change either a vertical or a horizontal motion to an oblique one. Diagram 9 is a double bent lever sometimes used to convey a motion in two different directions at the same time, as will be seen by the arrows at W, W.

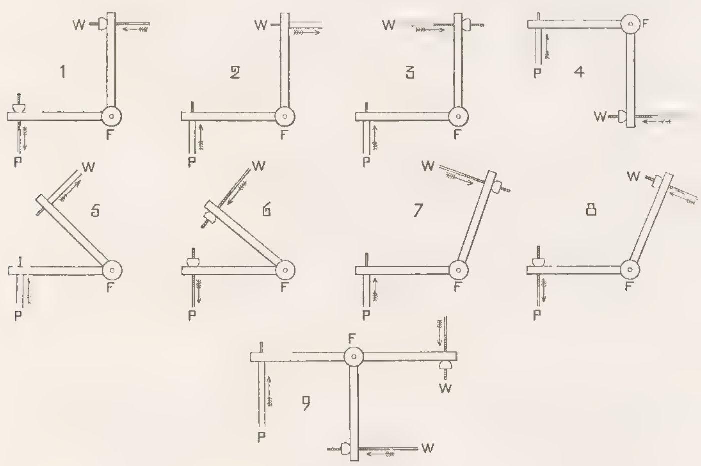


Fig. CXXVIII.

Compound levers are formed by the combination of two or more simple levers, and are frequently employed in the actions of Organs. The compound lever formed of two levers of the first order is very commonly met with in the coupling of tracker actions: and that formed of a lever of the first order and a bent lever, such as Diagram 1, Fig. CXXV., combined with Diagram 4 or 9, Fig. CXXVIII., has frequently been employed in key actions.

The levers freely used in the tracker action of the Organ are the parts known as backfalls and squares; the former being levers of the first order, and the latter bent levers. The parts designated rollers are also levers of a special construction. A roller may represent a lever of the first, second, or third order, according to the relative positions or lengths of its arms.

The *backfalls* are those portions of the tracker action which are employed to convey a motion a moderate distance, and, at the same time, to reverse its direc-

tion, hence their name—their back ends falling when their front ends are raised. Backfalls are strips of perfectly seasoned straight-grained wood, preferably light bay-wood, about 1⅛ inches to 1½ inches in width, and from $\frac{7}{32}$ inch to $\frac{5}{16}$ inch in thickness. Their length varies, according to circumstances, from a few inches to about 2 feet. In the case of long backfalls, care must be taken to select the lightest wood that will not be liable to warp. The usual form of the backfall is shown at A and B, Fig. CXXIX. Three holes are bored through the backfall: one through

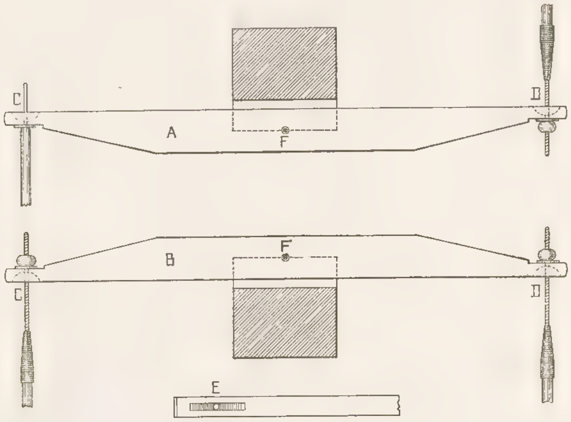


Fig. CXXIX.

the center at F, for the reception of the pin or wire which serves as the fulcrum; and the two others through the small ends at C and D, for the reception of the pins of stickers or the tapped-wires of trackers, as indicated. To enable the pins and wires to work freely, the ends of the backfall are slotted, or cut into by a small circular saw, finely toothed, about ⅞ inch in diameter, and about $\frac{1}{10}$ inch thick. The segmental form of these slots is indicated by the dotted lines at C and D; and at E is shown the edge of the backfall, drawn to a larger scale, with the slot in it. The central hole F must be bored sufficiently large to allow of being bushed with cloth, if desired, or to admit the free passage of a pin or tapped-wire.

Backfalls are usually supported by a beam of wood, across one face of which deep grooves are cut for their reception, and in which they are held in position by the wire passing through their central, bushed holes. The beam, which is commonly, but somewhat incorrectly, called the "backfall-frame," should be sufficiently large to remain absolutely rigid under the force of the action. It should rarely be less than 2½ inches square, while in some cases, when the beam is long, and carries a complete set of backfalls, and is supported only at its ends, it may with advantage be made 3 inches square, or even 3 inches wide by 4 inches deep. Sufficient depth is necessary because the beam is considerably reduced in this direction by the grooves cut for the reception of the backfalls. Every precaution

should be taken to counteract any liability to warp, and to this end it is desirable to form the beam of two equal thicknesses of wood, in its depth, strongly glued together. Different kinds of wood may be used with advantage; for instance, the portion to be grooved may be of close-grained mahogany and the other portion of

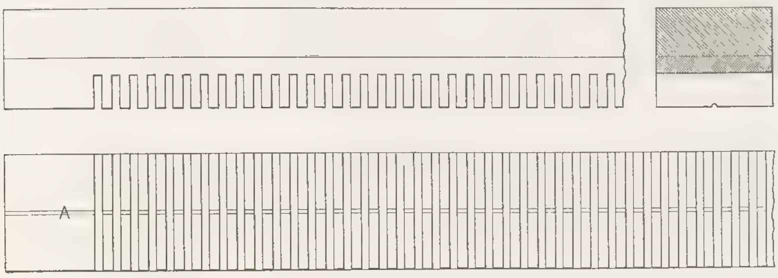


Fig. CXXX.

straight-grained white pine. Beams so formed are much less liable to warp than those formed of one piece of wood, however good and well seasoned it may be. The grooves are cut in the beam with a special grooving-plane, fitted with both side and face cutters, the plane being guided by a wooden bridge firmly held in position across the beam. The plane is adjusted so as to cut the grooves to a

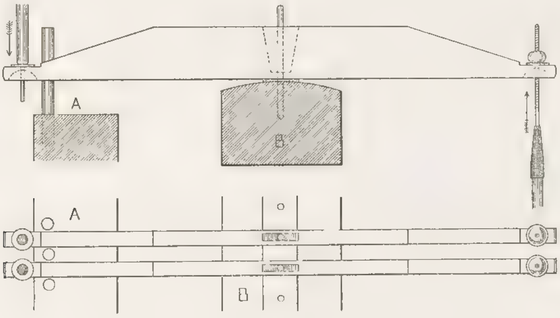


Fig. CXXXI.

uniform depth. In Fig. CXXX. are shown the side and the face of a grooved beam suitable for the reception of a set of manual key, parallel, backfalls. Only about half the length of the beam is drawn. The two lines along the face at A indicate a channel cut for the reception of the wire on which the backfalls are carried. This wire is held in the shallow channel by small wire staples. The grooves in

the beam are slightly wider than the thickness of the backfalls, and are carefully smoothed with glass-paper so as to prevent undue friction. They may be black-leaded with advantage in actions of a delicate character, such as those for small Chamber Organs. There is another method of carrying the backfalls on the beam shown in Fig. CXXXI. Instead of being hung in grooves, as above described, they are hinged on vertical pins, in the manner adopted for manual keys. This is a convenient method when the backfalls are likely to be removed at times. To prevent them from striking each other they should work in a comb, or on guide pins, at one end. The comb may be formed of round hardwood pins, slightly less in diameter than the distance between the backfalls, as indicated at A. The beam B is rounded on the upper surface, and has a narrow strip of leather or cloth glued along its center, on which the backfalls rest, as shown. When accurately fitted, the backfalls, in this system, work with very little friction. There are other methods sometimes adopted, but they are unworthy of being described here.

In the illustrations above referred to parallel backfalls have alone been shown; but we have now to direct attention to what is called the "fan-frame," in which the backfalls spread out like the brins of a lady's fan. This arrangement is usually employed, in the tracker action of small Organs, to spread the movement from the tails of the manual keys to the pull-downs of the wind-chest which are much farther apart than the centers of the key tails. In Fig. CXXXII. is given the Top View of portion of a fan-frame. At A are the ends of the backfalls which receive the stickers from the tails of the manual keys, and at B are the spread ends which receive the pull-downs (trackers or wires) of the wind-chest pallets. The upper surface of the backfall beam is shown at C; and at D are indicated, by dotted lines, the grooves cut in its under side, and the direction in which the center pins of the backfalls have to be set—at right angles to the backfalls. The center pins are short pieces of phosphor-bronze wire, let into notches cut in the beam, and secured by small wire staples or L-shaped turn-pins. While very little preparation is necessary in setting out the parallel backfalls, special arrangements have to be made for the correct setting out of the fan-frame. The whole disposition must be accurately laid down, full size, upon a drawing-board, or on a framework of planks to serve as one. On the board a line is drawn transversely from the center of the manual key line; and another center line is drawn longitudinally between the line of the sticker holes of the key tails and the parallel line of the wind-chest pull-downs. On the line of the key tails are marked the exact distances of all the sticker holes, and on the line of pull-downs are marked off, from the transverse center line, on both sides, the exact positions of the pull-downs. Diagonal lines drawn across the board, from the sticker holes to the corresponding pull-downs, indicate the direction of every backfall. This setting-out affords a ready means of accurately cutting the grooves in the beam for the backfalls. It must be observed that when the backfalls have to hang on the under side of the beam, as at A in Fig. CXXIX., the setting out of the fan-frame must be reversed on the drawing-board; so that, when grooved, the beam can be turned over and bring the backfalls into proper position. When the setting-out has been executed, as above directed, the backfall beam is temporarily screwed or clamped down,

over the longitudinal center line, on the board; and then a bridge of thick and squarely dressed wood, blocked up so as to rest tightly against the upper surface of the beam, is adjusted, on one side, to the diagonal lines of the backfalls, and nailed or clamped to the board at each end. Then the grooves are cut, one after another, with the grooving-plane held tightly against the side of the bridge. Absolute accuracy is secured by this simple method. A center line has to be scratched along the grooved face of the beam exactly corresponding with the longitudinal center line on the board below, and the beam is ready to receive the backfalls in their primary stage.

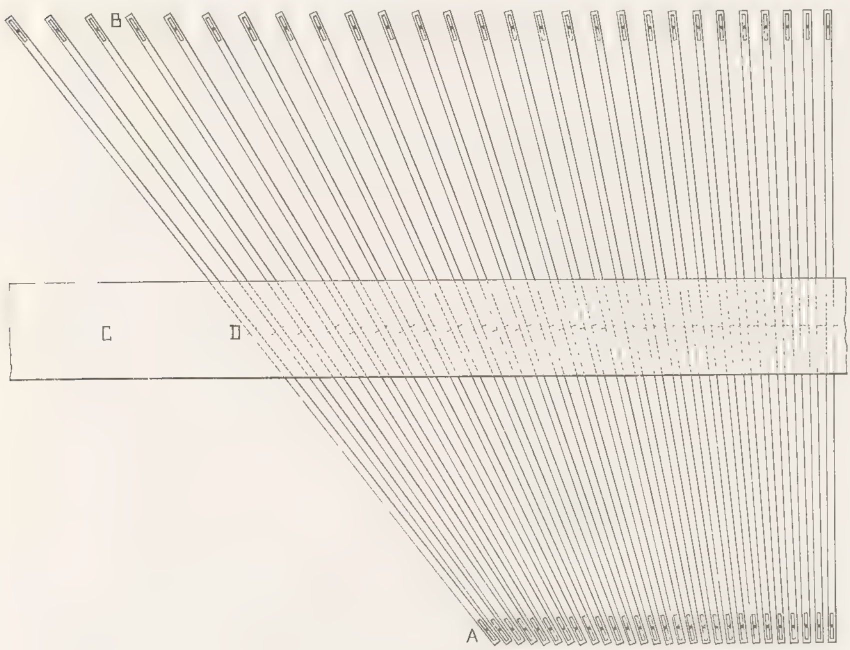


Fig. CXXXII.

The backfalls for the fan-frame are dressed accurately to the required width and thickness, and cut a little longer than their respective finished dimensions. The backfalls vary in length, as will be seen on referring to Fig. CXXXII. In the center of each is bored and bushed the hole for the fulcrum pin, and each backfall is then adjusted in its groove, the pin being properly bedded on the beam, and held temporarily in its place by the staples or the L-shaped turn-pins before spoken of. When all the backfalls are in position, their ends are

supported, and lines are scratched across them directly over the lines of the key stickers and the wind-chest pull-downs marked on the drawing-board below. The backfalls are now removed and numbered near either their front or back ends, and their fulcrum pins replaced on the beam. The next process comprises the shaping of the ends of the backfalls, and drilling and slotting them for the reception of the sticker pins and pull-down wires. In the first place, the backfalls have their ends sawn off uniformly at a distance of about 5/8 of an inch from the center of the lines that have been scratched thereon, as above described; and this determines the lengths of the backfalls, allowance being made for the subsequent dressing of their ends. The backfalls are now placed together side by side, with their front ends forming a straight line, and clamped tightly together between two wide pieces of wood of the same depth as the backfalls; and with proper planes the whole of the ends are dressed to the desired outline, and finished with glass-paper, and shellac polish laid on with a soft pad. The back ends are then brought together in like manner and shaped and polished. The backfalls are again placed in their grooves, and fresh lines marked across their finished ends to guide the drilling for the sticker pins and pull-downs. When the holes are drilled and slotted, the backfalls are permanently fixed in the beam, and the fan-frame is completed. The adjustment and shaping, etc., of the parallel backfalls are carried out in a manner similar to that described; but as all are of precisely the same length less labor attends their formation.

The backfalls above illustrated are all simple levers of the first order; but levers of the second and third orders, which are like half backfalls in shape, with

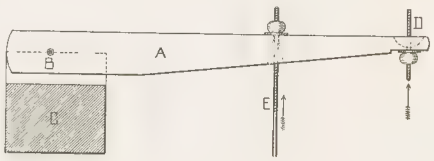


Fig. CXXXIII.

their fulcrum pins near one end, are sometimes used in certain kinds of action. Those of the second order are only employed when the power can be effectively exerted throughout a distance greater than that through which the load is required to move, while those of the third order are employed only on comparatively rare occasions when the load has to be moved through a greater distance than the power is required to exert itself. For instance, the lever of the second order can be used with advantage in the pneumatic lever action—the pneumatic motor expanding to a distance considerably greater than that necessary for the proper opening of the wind-chest pallet. In this case, the pneumatic lever motor is linked, by a tracker, to the free end of the lever arm; while the tracker which carries the motion to the pallet is connected with the arm somewhere between its fulcrum pin and its free end. Examples exist in the Organs in the Church of

Saint-Eustache and other churches in Paris. In Fig. CXXXIII. is given a drawing of this lever arm, which resembles, as has been already said, the half of an ordinary backfall. The arm A has its fulcrum pin at B, and is carried, in the usual manner, in the grooved beam C. The power is exerted, in an upward direction, at D, the tapped-wire there indicated being connected with the tracker from the pneumatic motor above, while the tapped-wire E is connected with the action which goes to the wind-chest pallet, etc. If the reader will now suppose the power applied at E, and the load to be at D, the arm A will represent, in all essential points, a lever of the third order. The direction of the arrows must be understood to be reversed, as the power (or pull) is exerted in a downward direction.

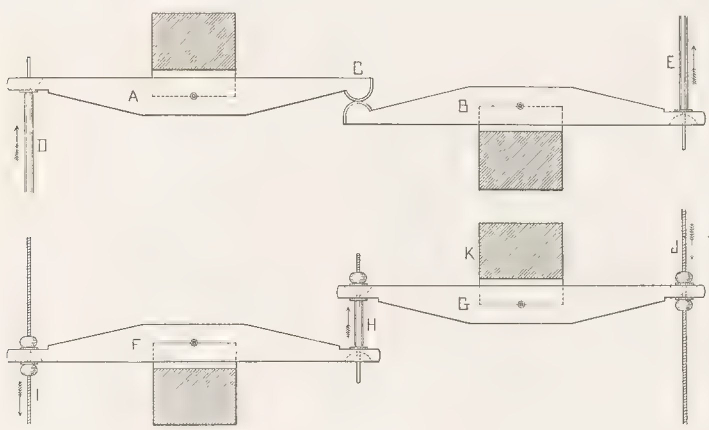


Fig. CXXXIV.

When the extreme ends of a lever action are required to move in the same direction, a compound lever, formed of two backfalls, is frequently employed. This compound lever may be straight or bent at any desired angle in a horizontal direction. The straight compound lever formed of two backfalls is represented in Fig. CXXXIV. In the upper diagram the backfalls A and B are not connected, their ends at C being rounded and covered with strips of leather, glued on with their dressed sides outward, and black-leaded to prevent undue friction. The power is applied by the sticker at D, the upward motion being carried to the other sticker at E. When properly made, this action is both light and silent. In the lower diagram the backfalls F and G are linked together by the short sticker H, which is furnished with a smooth pin at one end and a tapped-wire and button at the other, as indicated. The power is applied by the wire I, its downward motion being conveyed to the other wire J. Such an action as this is frequently used for coupling; it being only necessary to raise the backfall beam K about ¼ inch to throw it out of operation, the smooth pin of the sticker H allowing

this to be done. Lowering the beam immediately brings the action into operation again. In small Chamber Organs, in which the wind-chests are placed side by side and parallel to the claviers, double backfalls are very suitable for the octave and sub couplers. When so used they have, of course, to be carried diagonally the distance between the octaves of the two sets of pull-downs. In octave or sub couplers, acting on the same clavier, the backfalls forming the compound lever usually meet at an acute angle, as indicated in the Top View of one pair of backfalls given in Fig. CXXXV. At A is indicated, by dots, rather more than an octave of

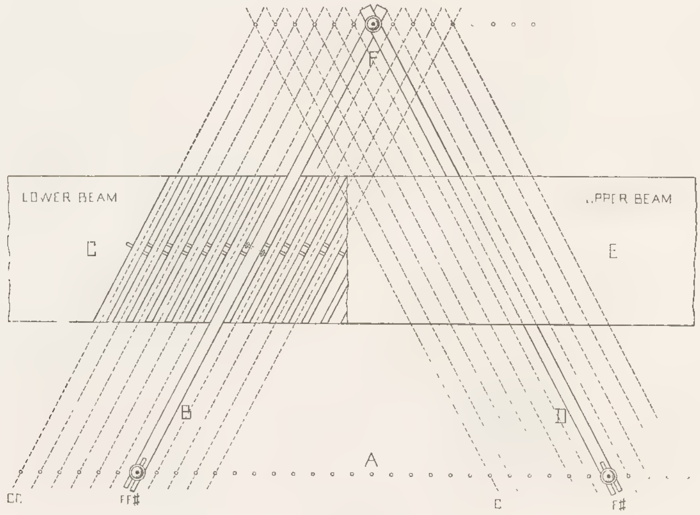


Fig. CXXXV.

pull-down or tracker wires belonging to a manual clavier. At B is the first or lower backfall, working in the stationary beam C; and at D is the second or upper backfall, working in the movable beam E. At F the backfalls are connected by a sticker (as shown at H in Fig. CXXXIV.), while the other ends of the backfalls are secured, by buttons, to the two pull-downs an octave apart. When the beam E is lowered, and the pull-down FF♯ moves the backfall B, the backfall D also moves and operates the pull-down an octave higher at F♯. When the beam E is raised, the motion of its backfall is stopped by the lifting of its sticker at F, and the coupler is put out of action for the time.

In Organs in which the action has to be compactly disposed, in different directions, to reach small wind-chests belonging to special groups of displayed pipes, compound levers, formed of three sets of backfalls, are sometimes necessary.*

* In the construction of our own Chamber Organ we introduced two series of compound levers, formed of three sets of backfalls, for the purpose of connecting the Pedal Organ roller-board with the two small wind-

The bent lever is largely used in tracker actions, in the form of the useful appliances called *squares*. Squares are commonly employed where an immediate change of direction is required in a tracker movement; or from a vertical clavier movement to a horizontal tracker one. Squares are formed of wood or metal, and vary in size according to circumstances. They should never measure less than 2½ inches from the fulcrum pin to the tracker eyes in the arms, while they may measure considerably more with advantage. The most approved form of wood square is that represented in Fig. CXXXVI. The square A is formed in the following manner: Cut off, across the grain, from the end of a ⅞ inch thick plank of mahogany, beech, maple, or some other close-grained hardwood, two pieces about 3½ inches in width, the length of which will be the width of the plank. Dress and shape the pieces, across the grain, to the exact form of one half of the square,

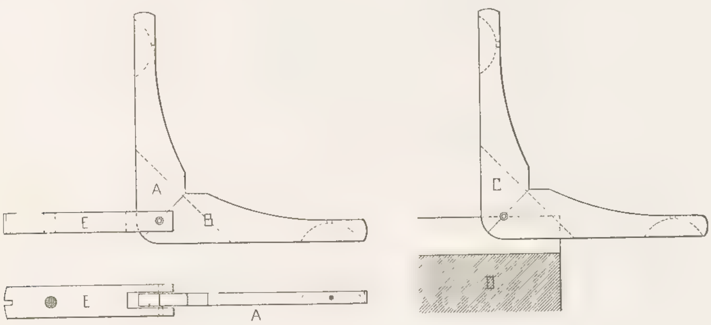


Fig. CXXXVI.

planing the miters perfectly true, and glue them securely together so as to form the entire square, as indicated. Then divide the pieces, so glued together, into equal parts, and line them off, each part being sufficient for a single square, allowance being made for the separating saw-cut and the final smoothing off with glass-paper. Now saw across the mitered angle, in the center of each divided part, for the reception of a thin veneer or feather of tough hardwood, as indicated by the diagonal dotted line across the Side View of the square at B, and securely glue the feather into the saw-cut. When all the feathers have been glued in, dress the projecting portions off cleanly, and after smoothing the entire surface with glass-paper, polish it with shellac and spirits of wine, laid on with a soft pad or rubber. Now cut off each square with a fine-toothed circular saw, remove the marks of the saw with fine glass paper (glued on a level board), and finish it by drilling a small hole near the corner for the fulcrum pin, and forming the slotted eyes at the ends of the arms for the trackers, etc.

chests located underneath the row of decorated wood pipes which extend across the central flat of the instrument. These levers are so disposed as to pass around the front standards of the building-frame, and to act on pull-downs at right angles to the stickers from the roller-board.

Squares made of wood, when placed parallel to each other and close together, are commonly mounted in a grooved beam, in the manner already described for parallel backfalls. In this case the fulcrum holes are bushed with cloth, and the squares are carried on a long wire of phosphor-bronze, let into a small groove run in the beam, and held in place by wire staples. At C is shown the square in the groove of the beam D. When the squares are few in number, and are disposed in a radiating fashion, or, indeed, in any way save in close parallel order, they are most conveniently mounted in small, independent, stocks or pieces of hardwood, of the form shown at E in Fig. CXXXVI. In this case, the holes in the stocks are bushed with cloth, while the fulcrum pins are driven tightly through the small holes drilled in the squares, and move only in the bushed holes of the stocks. Each stock has, in addition to the fork for the reception of the square, a hole drilled through it for the fixing screw, and a small notch cut in its back end for the reception of the wire pin that holds the stock firmly in the required direction.

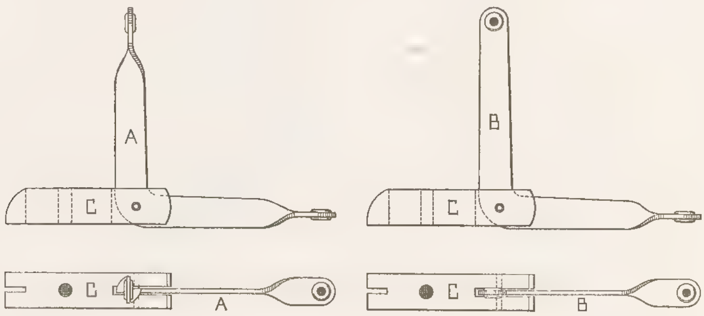


Fig. CXXXVII.

When the square has to be secured in its proper position, the stock is screwed down to the bearer or beam with a round-headed screw, and, when accurately adjusted, a wire pin is driven down in the end notch. This arrangement is peculiarly convenient for adjustment and allows any square to be removed and refixed at pleasure without disturbing the others. Squares so constructed are much better adapted for radiating and oblique actions than backfalls; indeed, their use is imperative, in conjunction with trackers, in actions which are of greater lengths than are safe for backfalls.

The best squares, and those which are now used in first class organ-building, are made of metal, preferably of aluminium.* These are punched or cut from the sheet metal; have their fulcrum holes drilled where their arms meet; and have the ends of their arms twisted at right angles, and drilled and bushed with leather.

*Aluminium squares are now largely used by English organ builders. They are extremely light and do not corrode.

The leather eyes are put in with an eyelet machine specially constructed for the purpose, large countersunk holes being drilled in the arms for the reception of the leather. The usual forms of the metal squares are given in Fig. CXXXVII. A is the square with both its arms twisted for the reception of tapped-wires or sticker pins, while B is a square with one arm left untwisted for the reception of a tracker hook (such as is shown in Figs. CXX. and CXXIII.), the other being twisted for a sticker pin or tapped-wire. Metal squares are carried in small stocks of hardwood, as indicated at C, formed in precisely the same manner as those previously described for the wood squares, and secured in position by the same means. Squares with both arms untwisted are sometimes used when they connect two trackers, their eyes receiving the hooked ends of the same.

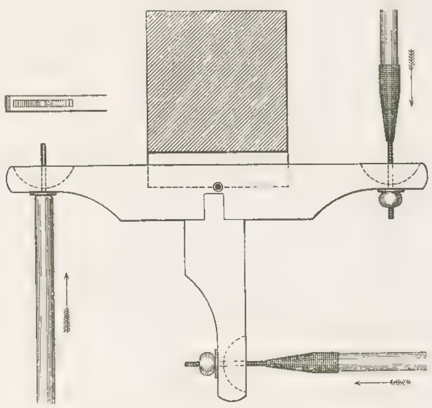


Fig. CXXXVIII.

The squares illustrated in Figs. CXXXVI. and CXXXVII. have their arms of equal lengths; but in some forms of action squares with unequal arms are introduced. These squares, owing to their unequal leverage, are only suitable when the pneumatic lever is used, which has a greater motion than that demanded by the wind-chest pallets. They may be used in simple tracker actions, when it is necessary to gain a motion slightly greater than that imparted by the key action, but as the leverage adds weight to the key touch, their introduction is not to be recommended. In properly adjusted and skilfully constructed tracker actions squares with unequal arms are not at all necessary, and, indeed, should never be used. Squares of a T-form, which show the combination of a backfall and a square, are occasionally used when motions in different directions are required at the same time. One of usual form is illustrated in Fig. CXXXVIII. This can be actuated either by a sticker or a pull-wire, the other arms being connected with trackers, which are pulled in both a vertical and a horizontal direction, as indicated in the drawing.

Bent levers, with their arms placed at an acute or an obtuse angle, may be constructed either of wood or metal in a similar manner to the squares above described. These are usually employed in draw-stop actions, or for some special oblique movement.

A *roller* is that part of an organ action which is introduced for the purpose of carrying, in a parallel direction, a vertical or horizontal motion to a point more or less distant from the starting point of the motion. Rollers are largely used in the tracker action, being the most convenient means of spreading the necessarily narrow movement from the claviers to the wider stretch of the wind-chest mechanism. A roller is, strictly considered, a lever, the fulcrum of which is prolonged in the form of a pivoted bar or rod; and the arms of which are attached to the fulcrum bar at or near its opposite extremities. The two arms may project from the same side of the bar, when their motion will be similar and parallel, and the roller will represent a lever of the second order. This is the form most frequently introduced in tracker actions. The arms may occupy positions on oppo-

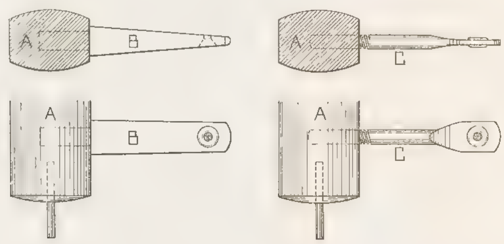


Fig. CXXXIX.

site sides of the bar, when their motion will be contrary and parallel, and the roller will represent a lever of the first order. This form is used when one arm of the roller is moved by a sticker while the other moves a tracker; or when a contrary motion has to be carried some distance between two trackers. We have said above that rollers are employed for carrying a motion in a parallel direction, and this is usually the case, but sometimes they are employed to carry it in an angular direction—commonly rectangular—the two arms being attached to the roller at the angle required. In this case, the roller represents a bent lever.

Rollers are made either of wood or iron. In old work they were invariably made of wood; but in modern organ-building they are usually made of iron, many advantages attending its adoption. A wooden roller consists of a bar or rod of clear white pine or some light straight-grained wood that is not liable to warp or twist. The rod varies in width and thickness according to its length and the work it has to do. It should never be less, even in very short rollers, than ⅞ inch wide by ⅝ inch thick, while its average dimensions are 1 inch wide by ¾ inch thick. The rod has its sides rounded, as shown in the Transverse Sections at A, Fig. CXXXIX., so that, when fixed on the roller-board, it may rock on its axis

without coming in contact with the other rollers placed closely alongside of it. The ends of the rod are made slightly convex so as to prevent unnecessary friction against its supporting studs. Pins of phosphor-bronze are inserted in the center of the ends of the rod to serve as pivots. One of these is permanently fixed and left projecting about $\frac{1}{2}$ inch, while the other should be longer, have an eye turned on its outer end, and be made movable, so as to allow the roller to be inserted between its fixed studs, and removed and replaced at pleasure. In some instances rollers have been pivoted in bent metal supports, which permit them to be sprung into their places and removed at any time; in this case the pins at the ends of the rollers are very short and permanently fixed. The wooden roller is completed by the addition of two or more arms, which are inserted in one or both of its flat faces, usually close to its ends. The arms may be made of hardwood or of metal. The usual form of the wooden arm is shown at B in Fig. CXXXIX.; it is secured to the roller A by a turned end, glued into a hole bored for its reception, as indicated by dotted lines. Metal arms, usually iron, were used for wooden rollers in old work, as is clearly shown in Plate LX. of the important treatise by Dom Bedos. These are represented as slender, and with small plain eyes for the reception of tracker hooks. The iron arms of proper form are shown at C in Fig. CXXXIX. They are made from wire about $\frac{5}{32}$ inch diameter, tapped at one end, and flattened out at the other for the reception of the leather eye, as shown. They are tightly screwed into the wooden rod where required, and are adjusted for the reception of sticker pins, tapped-wires, or tracker hooks, according to the requirements of the action.

Iron rollers are made of $\frac{7}{16}$ inch diameter drawn tubing, cut to the required lengths, and plugged with hardwood at their ends for the reception of the pivots or pins of phosphor-bronze. Holes are drilled through the rollers for the reception of the arms, which are similar in form to the iron arms shown at C in Fig. CXXXIX., and which are riveted in the holes so as to be perfectly firm. There are several advantages attending the use of iron rollers: they occupy much less space than wooden ones; they do not warp or twist; they have no tendency to spring in action; they are not affected by damp or drought; and they have a much neater appearance. Iron rollers are usually black-japanned to prevent their rusting. Aluminium arms would be much better than iron ones.

Rollers are supported on the face of a board or frame, properly designated the roller-board, by means of studs pinned into, or screwed to, the same. The studs are commonly made of beech or some close-grained hardwood, drilled and bushed with cloth for the reception of the pivots of the rollers. The hole in the stud is so formed that the pivot of the roller bears only for about $\frac{3}{16}$ inch within it; it is accordingly bushed so far, and friction is reduced to a minimum. Between the ends of the roller and its supporting studs small washers of cloth should be placed to prevent any noise from a lateral movement of the roller. In all parts of an organ action every precaution should be taken to eliminate any cause of noise or unnecessary friction. Front and Side Views of the wooden stud, in its usual form, are given at A in Fig. CXL. The lower part, which is round, is for insertion into the roller-board. Different forms of metal studs have been used, the

simplest of which is shown at B. This is a bent plate of brass or phosphor-bronze, drilled, and bushed with leather put in with an eyelet machine; it is fixed to the roller-board by two screws, as indicated. At C is shown an ingenious metal stud, which serves as a spring, holding the roller firmly in position, yet allowing it to be removed and replaced at pleasure. This should be formed of hard rolled brass and may either be drilled to accurately fit the pivot of the roller, or drilled and furnished with an eyelet of leather for the same. The middle fold of the spring, bearing on the rounded end of the pivot, holds the roller D in correct lateral position with very little friction. The pivot should be lubricated with pure black-lead.

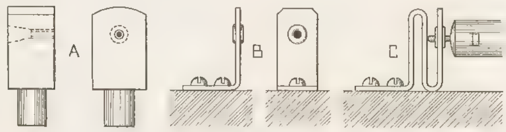


Fig. CXL.

Rollers have frequently to be made of considerable length, and these may require more support than is provided by the pivots at their ends. When a roller is so long as to be liable to swag, or to vibrate while being moved, it should be divided in the middle, and carried there by being pivoted in a double-bushed stud. The two divisions of the roller must be connected, across the central double stud by an *accolade*, bridle, or bridge-piece of metal, so that they may move together like a single roller. The simplest form of connection is shown at A in Fig. CXLI. It consists of a piece of thick iron or brass wire, bent so as to allow

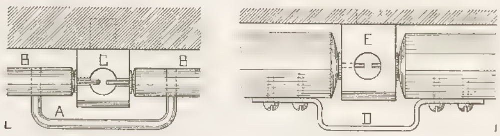


Fig. CXLI.

its ends to pass through holes drilled in the iron rollers B. One end should be riveted tightly into one of the rollers, while the other should be movable. The central stud C is drilled, slotted from above, and bushed or lined with cloth, so as to allow the pivots of the rollers to be dropped in while the rollers are connected. The simplest method of connecting wooden rollers over a central stud is by a narrow strip of sheet iron or brass, bent and screwed on in the manner indicated at D. As this bridge-piece is easily fixed after the rollers are in place, the central stud E does not require to be slotted. More complicated methods of connecting divided rollers have been devised, but as they do not present commensurate advantages it is unnecessary to describe them here.

Rollers are mounted either on boards or frames, the latter being adopted when the rollers are numerous and extend to a considerable length. The frames are so formed as to carry all the roller studs exactly where they are required by the rollers of different lengths. The frames are securely mortised and tenoned at all joints, and glued and pinned so as to make everything safe. When only a few rollers are associated together, a solid plank or board of the necessary width is commonly used, but in all possible cases a frame is to be preferred.

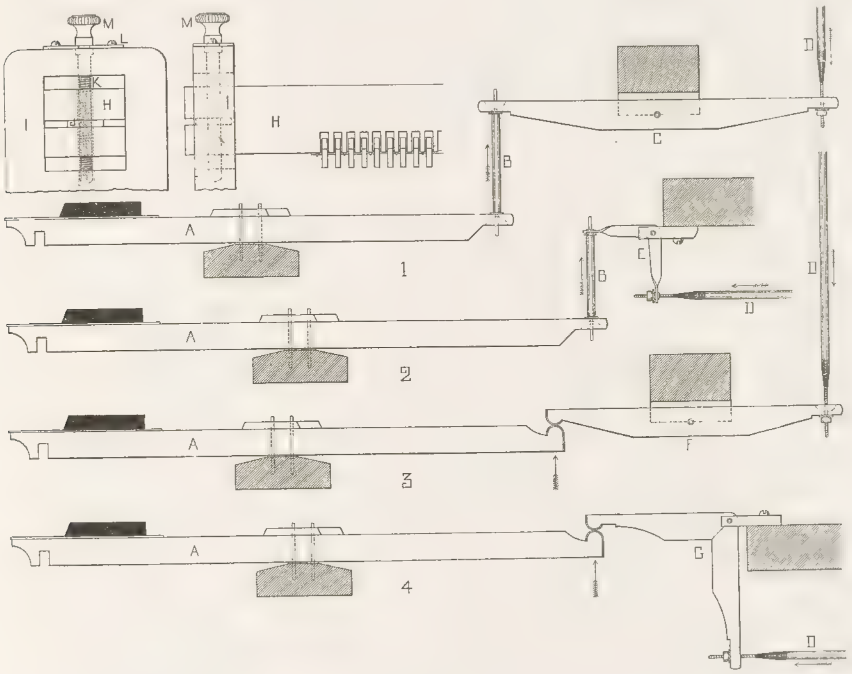


Fig. CXLII.

Having described at sufficient length the different parts which form the ordinary tracker action, we may now consider their general disposition and treatment in the representative forms of that action.

In the manual department of an Organ the action proper starts at the tails of the keys, which rise as the front portions are depressed by the fingers of the performer. The key tails in rising exert either an upward pushing motion, usually through the agency of stickers, or by acting directly on horizontal backfalls or inverted squares; or, as in the case of an Organ having a reversed console, an upward pulling motion through the immediate agency of trackers. In the former arrangements the action extends either vertically or horizontally from the tails of

the keys, while in the latter it is carried down below the claviers and extends underneath the floor or platform on which the console and organ-stool are placed, as in several large modern French Organs. In the upward pushing motion the stickers that rise from the key tails actuate backfalls, which transform the upward pushing motion to a downward pulling one, suitable for the extension of the action by means of trackers, as indicated in Diagram 1, Fig. CXLII. A is the manual key, B the sticker, C the backfall, and D the tracker. The arrows indicate the directions of the movement. In another arrangement, the stickers actuate inverted squares which transform the upward pushing motion to a horizontal pulling one in the manner indicated in Diagram 2. A is the key, B is the sticker, E the inverted square, and D the horizontal tracker. In both these movements the stickers may be dispensed with, and the backfalls and squares be brought into direct contact with the tails of the keys, as shown in the Diagrams 3 and 4. In the former the backfall F has one end shaped with a small segmental portion, which bears on the tail of the key, similarly shaped, and covered with smooth leather, well black-leaded. In Diagram 4, the square G, made of wood, and of larger size than usual, has one segment-shaped end which bears on the segmental part of the key tail, leathered and black-leaded to prevent noise and friction. In both these diagrams the directions in which the trackers D extend and move are shown. The backfalls C and F, in Diagrams 1 and 3, may continue the lines of the keys and lie parallel to each other; or they may be disposed fanwise when it is considered advisable to give a larger width for the numerous vertical trackers than is provided in the claviers, and is compulsory for the stickers or the ends of the backfalls in contact with the key-tails. When squares are used, as in Diagrams 2 and 4, the action should be carried parallel, in the lines of the keys, if it is to be satisfactory in all respects.

In the action, as it immediately leaves the keys, it is always desirable, if not absolutely necessary, to provide some efficient and easily accessible means of increasing or reducing the depth of the touch of each manual clavier throughout its compass. This is best accomplished by providing a vertical screw adjustment for the horizontal beams that carry the backfalls or squares. Raising the beams will reduce the key touch, while lowering them will depress the key tails and deepen the touch. A very efficient form of screw adjustment is shown in the upper part of Fig. CXLII. H is the end of the backfall beam which passes through the oblong opening cut in the support I, and in which it can be raised or lowered. A slot is cut in the end of the beam to receive and hold tightly a square brass nut, shown at J. Passing through holes bored in the upper part of the support and in the end of the beam is the adjusting screw K, which is held in its place by the plate L. This plate, by being notched so as to fit into a groove turned in the knob M, as indicated, prevents the adjusting screw from moving in a vertical direction. When the knob M, which is fixed to the screw K, is turned, the screw below, working in the nut held in the slot of the beam, raises or lowers the beam while it holds it firmly at any level. This screw adjustment is fixed at each end of the beam, so that the touch can be equalized throughout the clavier.

In the case of the upward pulling motion commonly met with in the key

action of the reversed console, as before stated, trackers descend directly from the tails of the keys until they reach convenient points under the level of the platform, where they engage the arms of inverted squares. Other trackers, attached to

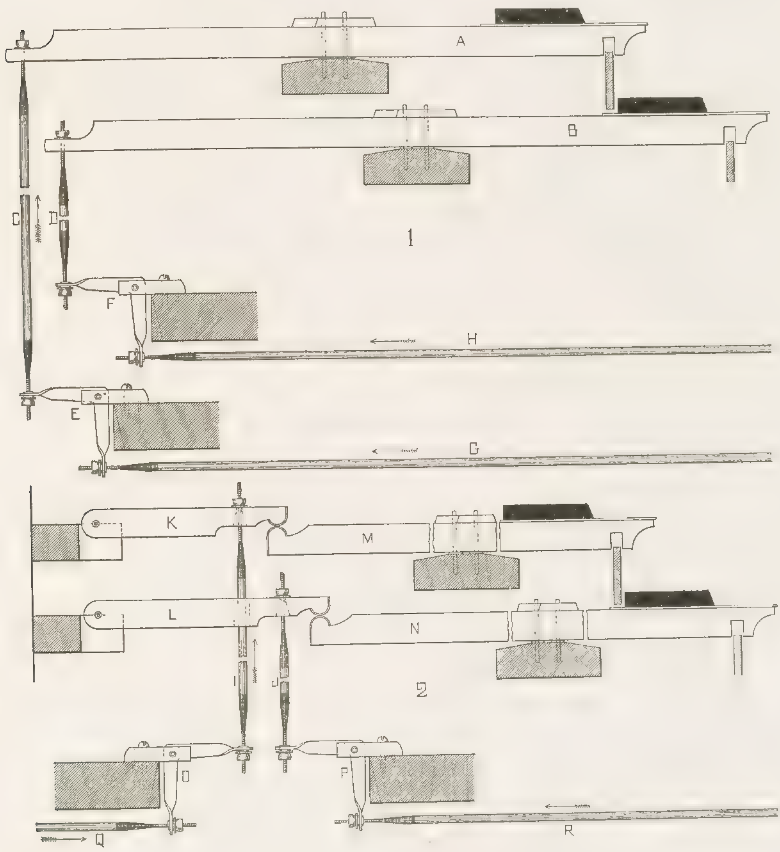


Fig. CXLIII.

the pendant arms of the squares, carry the action in a horizontal direction under the platform and into the interior of the Organ. A fine example of this action is furnished by the Grand Organ in the Church of Saint-Sulpice, at Paris.* When

* Good Plans and Sections of this Organ are given in Plates LVII., LVIII., and LIX., of "Die Theorie und Praxis des Orgelbaues," by Töpfer-Allihn.

a detached console is placed midway between two portions of an Organ, as in the case of the Grand Organ in the Church of Saint-Vincent de Paul, at Paris, the horizontal tracker-work is carried in both directions from the console, under the platform, into the two portions of the instrument. In Fig. CXLIII. are given diagrams illustrating the movements above described. Diagram 1 shows the trackers C and D carried downward from the tails of the keys A and B, and connected with the inverted squares E and F which are located below the level of the floor on which the console rests. These squares change the vertical pulling motion to a horizontal pulling one, the latter being conveyed, under the console and its platform, into the interior of the Organ by means of the horizontal trackers G and H. This is the form of action adopted by Cavaillé-Coll, in the Grand Organ of the Church of Saint-Sulpice. The arrows indicate the direction of the motion which attends the depression of the keys under the hands of the performer. The trackers C and D, which have to be several feet in length, are necessarily shown broken in the diagram. Diagram 2 shows another form of this action, in which the vertical trackers I and J are connected with the levers K and L which rest on the tails of the keys M and N. This arrangement allows the keys to be removed without disturbing the adjustment of the action. The trackers I and J are connected at their lower ends with the inverted squares O and P; and these in turn are connected with the horizontal trackers Q and R, which convey the pulling motion, in contrary directions, to the two portions of the Organ commanded by the respective claviers, as indicated.

In the reversed console key actions, as above described, the mechanism coupling the manual claviers to the pedal clavier acts on the vertical trackers, engaging them, by means of backfalls, a short distance below the manuals.

Having considered at sufficient length the different mechanical parts of the tracker action immediately attached to the manual claviers, we may now follow the trackers, connected with the backfalls and squares, as shown in Figs. CXLII. and CXLIII. farther into the Organ on their way toward the pull-downs of the wind-chest pallets.

When the vertical trackers are long, in any part of the Organ, means must be taken to prevent their swinging from the vertical line and striking against each other when suddenly pulled or released. There are two methods commonly adopted with this view. When the trackers are in the shape of flat strips, and each is constructed of a single strip of wood, they are commonly held in position by being made to pass through a guide or register of wood of the form shown at A in Fig. CXLIV. Care must be taken to so finish this register that very little friction is caused; and everything must be made perfectly smooth. It is advisable to cut the slots in the register in the manner indicated at B, so that the trackers only come in contact with their upper edges; and these should be well black-leaded, along with the parts of the trackers which come in contact with them. When the trackers are too long to be conveniently made in single lengths, or when they are rounded in form, they are properly held in position and the divisions connected together by the simple appliance shown at C. This is a small arm, stamped from sheet brass or aluminium, pivoted at one end, and furnished at the other with two

eyes bushed with leather in the manner already directed for metal squares. The arm is inserted in the stock F, screwed in the required position to the supporting board D. Either flat or round trackers may be attached to the arm by means of copper or bronze wire hooks. Round trackers with hooks are shown at E. When properly constructed this support has no perceptible friction.

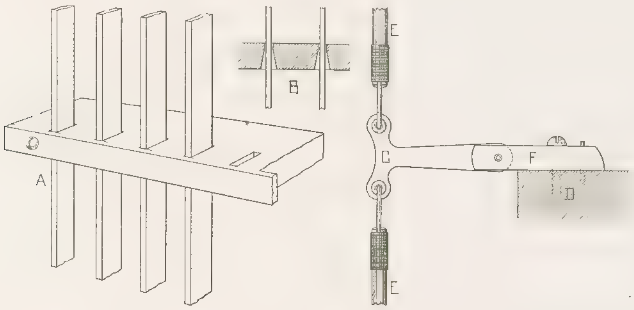


FIG. CXLIV.

Several methods of supporting horizontal trackers have been devised. Probably the simplest and, on account of the total absence of friction, the most satisfactory method is to support the trackers by strong linen or silk threads at the necessary intervals. The trackers swing easily and noiselessly on these suspended threads. When there is any liability of long trackers so supported striking each other when quickly moved, a comb of round wood pins may be so placed as to allow the trackers, when at rest, to pass between its teeth without touching them. Round trackers properly suspended in the above manner are not liable to spring so as to strike each other even when placed at key-distance apart. Round trackers are sometimes supported on transverse strips of wood, planed to almost a knife-edge, and covered with smooth cloth or leather, the latter being black-leaded. The portions of the trackers which rub against the leathered edges should also be black-leaded. If the trackers lie close together, and are liable to spring in action and strike against each other, wire pins may be planted between them along the bearing edge which supports the trackers in the middle of their length. When properly treated, this method of support causes little friction of an objectionable character; it cannot, however, be recommended for very long trackers which would require two or more bearers in their length. The most efficient and durable method of supporting long horizontal trackers—flat or round—is by means of small pendant arms of aluminium or brass, similar in all respects to the double-eyed arm illustrated at C in Fig. CXLIV. They are most suitable for use when the trackers are so long as to require to be in two or more lengths. A simpler support, suitable for horizontal trackers in single lengths, is formed of a piece of brass wire, about 4 inches long, having a circular eye turned at one end, by which it is

suspended on a transverse wire, and a hook bent up at the other, in which the tracker—flat or round—lies freely. The mode of support used by Cavaillé-Coll for the trackers from the reversed console of the Grand Organ in the Church of St. Sulpice, at Paris, is of this simple character. In the case of heavy trackers belonging to the pedal action, small, grooved, wood pulleys, running on a transverse wire, have occasionally been employed as supports; but this method has never come into common use, nor is it to be recommended.

We may now follow the trackers, after they leave the mechanism immediately connected with the keys, on their way to the wind-chests. In large Organs the distance between the claviers and the wind-chests may be considerable; and the trackers will in all probability have to change their direction from the horizontal to the vertical and from the vertical to the horizontal more than once in their course. They usually continue parallel until they reach the vicinity of the wind-chest, where the action has to be spread out so as to reach the pull-downs of the pallets. This spreading is commonly accomplished by what is known as the roller-board, which, as we have already said, is a board or frame of wood, carrying as many horizontal and parallel rollers as there are trackers or pull-downs. We have already described and illustrated the usual forms of rollers and the modes of supporting them, so it is only necessary now to describe and illustrate the general form and disposition of the complete roller-board. It must be noted that the form and disposition depend entirely upon the manner in which the pipes are planted on the wind-chest, or wind-chests, belonging to the manual from which the series of trackers extends. In the case of single or undivided wind-chests, three modes of planting may be followed. (1) The pipes may stand (as in the so-called "Simplification System") in the order of their respective notes in the clavier; namely, semitonally from the CC pipe on the extreme left to the c⁴ pipe, on the extreme right, of the wind-chest. (2) The pipes may be arranged with the CC pipe in the center of the wind-chest, and the other pipes alternately on each side of it, the b³ and c⁴ pipes standing respectively at each end of the wind-chest. (3) The c⁴ pipe may be planted some distance to the right of the center of the wind-chest, and from it, in proper semitonal succession, the pipes are carried to the left until the tenor C pipe is reached, then the bass octave is disposed alternately to the right and left of the pipes already planted, the pipes on the right being BB, AA, GG, FF, DD♯, and CC♯, while those on the left are AA♯, GG♯, FF♯, EE, DD, and CC. Sometimes ten pipes are carried to the right of the c⁴ pipe, when the first pipe moved out of the proper succession is G. In the case of a wind-chest divided into two sections, having, as is usually the case, a passage board between them for tuning, etc., the pipes are arranged tonally on each section, the b³ and c⁴ pipes being planted adjoining the passage-board, while the bass pipes CC and CC♯ occupy the outer ends of the sections. For further particulars on this subject the reader may turn to the following Chapter on the Slider and Pallet Wind-chest.

It is quite obvious that for each of the four plantings above described the arrangement and form of the roller-board must be different; for in all cases the actuating trackers remain in the direct semitonal order of the manual keys.

It is possible that in some special cases there may be smaller roller-boards required to carry the vertical trackers to the right and left on the same plane; and these will occupy positions somewhere between the claviers and the large roller-boards adjoining the wind-chests. It must be observed, however, that in all plain tracker actions as few mechanical movements, or changes of direction, must be introduced as possible; for every change creates additional friction, adds undesirable weight to the key touch, and increases the liability of the action to go out of order. Every center or bearing that can by any means be dispensed with should be dispensed with; for however carefully all pivots are bushed, and squares, backfalls, and rollers are centered and fitted, there will be objectionable elements of friction to contend with. We are specially alluding to the plain or simple tracker action, unaided by any appliance such as the pneumatic lever. When a powerful agent of this kind is introduced, the matter of a little additional friction between it and the wind-chest pallets need not be considered; it is then only necessary to prevent all undesirable friction in the action which extends from the claviers to the valves of the pneumatic levers.

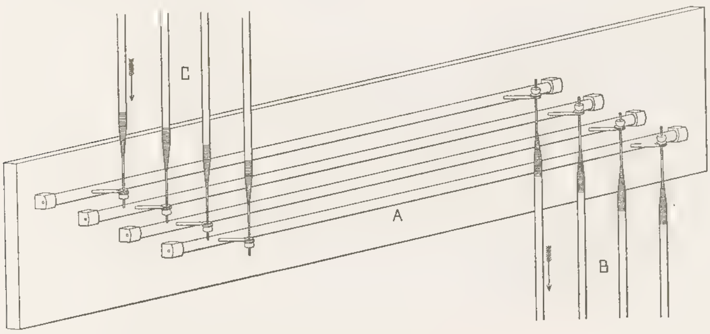


Fig. CXLV.

The general principle of the roller-board action is shown in the accompanying Perspective Drawing, Fig. CXLV. The rollers A are pivoted at each end in studs fastened to the supporting board. The descending trackers B are supposed to come from the key movement, while the ascending trackers C are those connected with the pull-downs of the wind-chest. It will be observed that when any one of the trackers at B is pulled down by the key movement, the corresponding tracker at C linked to the arm of the same roller is likewise moved down, as indicated by the arrows. It will also be observed that while the trackers at B may have to be key-distance apart, there are no restrictions as to the positions of the trackers at C, either as regards their distances from the key tracker or from each other. The latter will vary according to the setting-out of the wind-chest. In Fig. CXLVI. is given a diagram showing the front of a German manual action roller-board, and the manner in which the movement is carried alternately to the

right and left from the key trackers to the pull-downs of the two sections of the wind-chest.* The series of trackers which is connected with the key movement is shown at A. Each tracker is attached to a roller arm by a wire hook, the second arm of the roller being similarly linked to an ascending tracker which is connected to a pull-down of a pallet of the wind-chest above. The pull-down trackers are shown at B. As both series of trackers are numbered 1 to 52, the mode in which the action is extended and carried alternately to the left (or the C) and right (or the C♯) wind-chests can be readily traced.

Roller-boards are also commonly introduced in pedal clavier actions, both for the purpose of carrying the movements in lateral directions beyond the extent of the claviers, and for the purpose of gathering the movements together directly under the lower keys of the manual claviers for the operation of the manual to pedal couplers. In the coupler roller-board the rollers are so arranged as to require as little height as possible; they are, accordingly, arranged in groups, carrying the action in as direct a manner as practicable from the ends of the pedal keys to the coupling backfalls under the thirty or thirty-two lower manual keys. Different arrangements can, of course, be adopted. One arrangement is given in Fig. CXIX., in the preceding Chapter on the Pedal Couplers, accompanied by a full description of the roller-board, trackers, backfalls, and the other necessary parts of the action.

In Chamber Organs and in other instruments of small size it is not unusual to carry the pedal action proper to each side by means of a long roller-board, the notes, from CCC to F or G, being carried alternately to the left and right. For this mode of construction a special arrangement of long iron rollers is required, which will embrace the coupling action above alluded to, and illustrated in Fig. CXIX. In this case each roller will require three arms—one for the tracker from the pedal key; one for the tracker or tapped-wire to the coupling backfall or backfalls; and one for the sticker or tracker connected with the action which extends to the pull-down of the pedal wind-chest. It may happen that the position of the pedal wind-chest requires the roller arms connected with its action to move in a contrary direction to the other arms, and engage pull-up trackers or push-up stickers. The arms so placed must pass through the board or frame on which the rollers are supported, oblong holes being cut for their passage where required.

In old organ-building small or very short rollers supported between parallel pieces of wood were very commonly used; but these rollers merely filled the office squares do in modern work. There are, however, still some cases in which such short rollers are useful and to be preferred to squares, notably when it is desirable to have the arms somewhat apart or when trackers are required to pass over each other. The accompanying illustration, Fig. CXLVII. (after an engraving given by Dom Bedos) shows portion of a tracker action in which a series of short rollers are used for both direct and crossing trackers. The front piece of wood is removed so as to allow the rollers to be completely seen. At the time

* This illustration is reproduced from the engraving in Plate XXXII. of "Die Theorie und Praxis des Orgelbaues." It shows a short German manual compass of 52 notes.

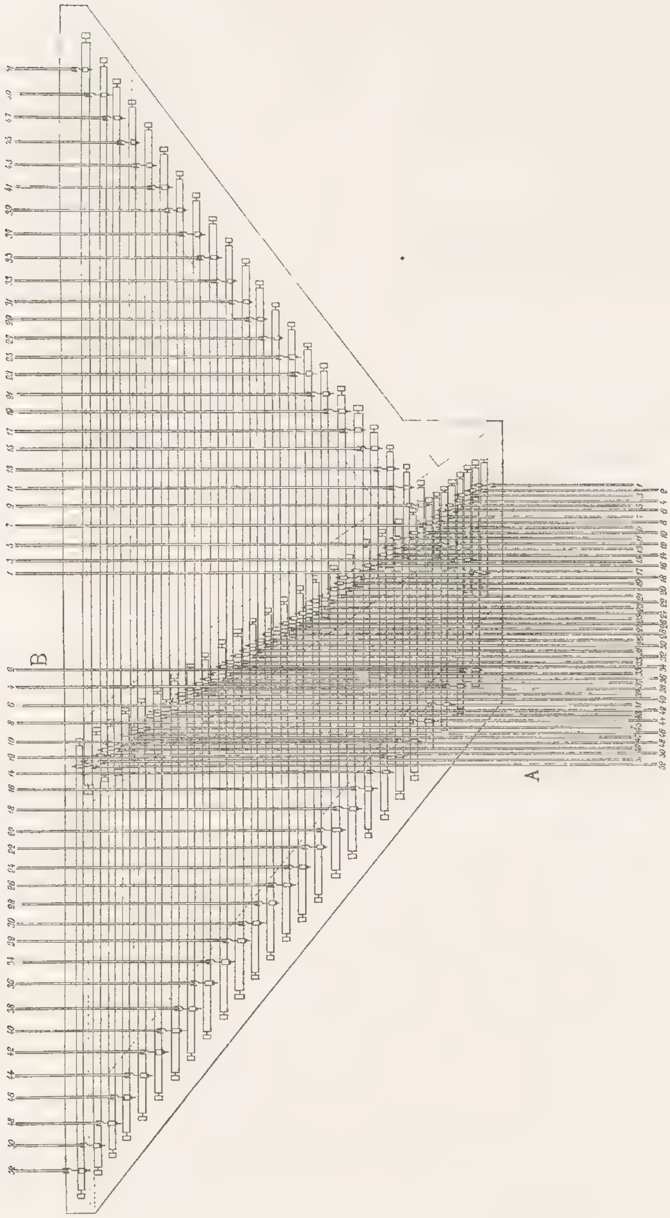


FIG. CXLVI.

Dom Bedos wrote, these short rollers were commonly used in pedal actions. The illustration here given is part of a pedal action, the vertical trackers being those from the pedal keys; the horizontal trackers are connected with other series of short rollers, which carry the trackers both vertically and obliquely to the lateral wind-chests of the Pedal Organ.

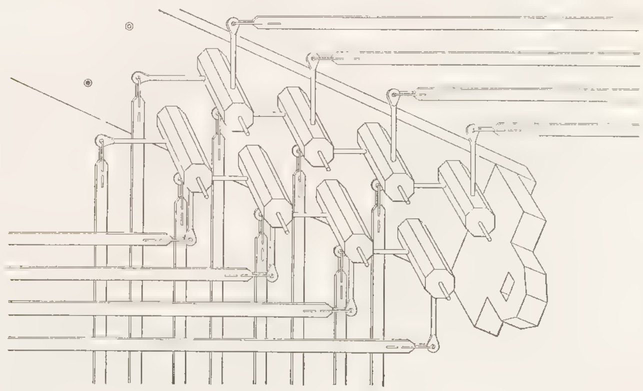


Fig. CXLVII.

In the preceding remarks, with reference to large roller-boards, allusion has been made only to those which occupy vertical positions; but series of rollers are frequently placed on boards, or in frames, laid horizontally or obliquely, notably

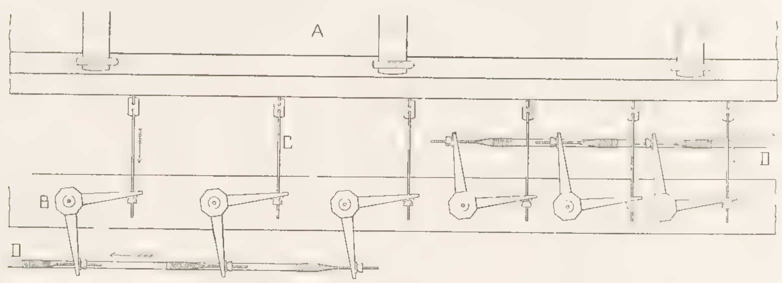


Fig. CXLVIII.

in pedal tracker actions. In such actions they are commonly placed under wind-chests, acting directly on the pull-downs of the pallets; the trackers which actuate them being carried in a longitudinal direction under the wind-chests. The two motions of the roller arms are in such cases at right angles to each other. The manner in which this portion of a tracker action is arranged is shown in Fig.

CXLVIII. Portion of a pedal wind-chest is indicated at A. The rollers, with their arms at right angles, are shown in end view at B; the pull-downs at C; and the trackers at D, D. The directions of the pulls are indicated by the arrows. When the pull-downs are so widely apart as to admit of the ordinary armed rollers being placed between them, the arrangement shown in Fig. CXLVIII. is all that can be desired; but sometimes the pull-downs are located too closely together to admit of the use of horizontal rollers with the ordinary straight arms. When this is the case, all difficulty is overcome by using rollers furnished with metal arms projected obliquely from their pull-down ends. This arrangement is shown in the accompanying illustration, Fig. CXLIX. It will be seen that it admits of an

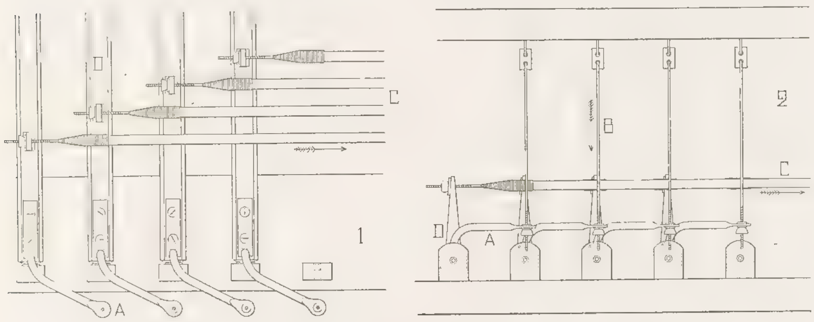


Fig. CXLIX.

extremely close arrangement of pull-downs, which pass through the bushed eyes in the projecting arms at A. The pull-downs are indicated at B; and the actuating trackers are shown at C, linked to the upright straight arms of the rollers D. A roller-board of this description may be used for a manual wind-chest when the location of the latter renders it necessary for the actuating trackers to approach it in a longitudinal direction. This class of roller-board is also suitable for a pedal key action, the oblique arms A being placed under the ends of the keys, and connected with them by short stickers. Trackers linked to arms placed above and below the rollers at the proper points, transmit the action to both sides of the Organ, close to the floor on which it stands.

While a general idea of the simple or unassisted tracker action may be readily gathered from the illustrations and descriptions of its component parts already given, a brief outline of some representative combinations of those component parts may assist the interested reader to form a more comprehensive idea on the subject. It will be remembered that the component parts of the simple tracker action are stickers, trackers, backfalls, lever arms, squares, rollers, and pull-downs. The employment of all or a certain number of these parts is dictated by the size and peculiar disposition of the Organ, and the skill of the designer is chiefly displayed in the employment of the fewest possible parts, as well as in their effective

distribution. As we have already remarked, all unnecessary friction must be avoided, and loss of action must be carefully guarded against, by having every center and point of junction in the action most accurately brought to a dead bearing. Unless this is done the key touch will be unpleasant, and the response to it both sluggish and imperfect. It must be borne in mind that the touch at the front of the manual keys should never exceed half an inch, while less is always desirable; and this small depth leaves little if anything for loss of action by indifferent adjustment. These remarks specially apply to unassisted tracker actions; or in those in which the pneumatic lever or any other pneumatic device is introduced, the action directly commanded by the manual keys is usually short, light, and very accurately adjusted, extending only from the tails of the keys to the small pallets of the pneumatic levers. Beyond the pneumatic levers the motion of the parts is greater; and while accurate adjustment is always desirable, a slight loss of action is not so serious as in the simple tracker system. Magnificent examples of pneumatic lever tracker actions, in which the fullest use is made of all the component parts above named, are to be found in the large modern Organs constructed by the leading French builders, notably in the Grand Organs in the Cathedral of Notre-Dame and in the Churches of Saint-Sulpice and Saint-Eustache, at Paris. Full particulars of the pneumatic lever are given in the Chapter devoted to that mechanical appliance.

The simplest form of action for connecting the manual keys with the wind-chest pull-downs consists of a fan-frame, the front ends of the backfalls of which are connected with the tails of the keys by stickers, while the back ends of the backfalls receive the pull-downs. This form of action is shown in Diagram 1, Fig. CXLII. When the wind-chest is considerably elevated, the backfalls will be connected with the pull-down wires by trackers of the usual form; but when the wind-chest is only a short distance above the clavier, tap-wires will take the place of the wooden trackers. In the small Organs in which a simple and direct action of this class is called for, it is usual for the lowest octave, or octave and a half, of pipes to be planted alternately on each end of the wind-chest. This arrangement necessitates the introduction of a roller-board to carry the movement from the CC♯ and other alternate keys to the right hand end of the wind-chest, where the roller arms are connected by stickers with the front ends of the corresponding backfalls. The arms at the left hand ends of the rollers are connected with the tails of the keys by stickers, in the same manner as the adjoining backfalls. When the wind-chest is planted semitonally throughout the compass of the instrument, all the bass pipes will be at its left end, and no rollers, as above mentioned, will be required; but a few short rollers may be found desirable to extend or spread the action somewhat at the bass end of the clavier, and so prevent the introduction of inconveniently disposed backfalls, or those of too great a length.

Another simple action between the keys and an adjacent wind-chest is formed with parallel backfalls, connected with the tails of the keys either by stickers in the manner shown in Diagram 1, Fig. CXLII., or by direct contact, as indicated in Diagram 3, the rear ends of the backfalls being connected with vertical trackers (shown at D in the diagrams) which ascend to a roller-board that dis-

tributes their motion to the pull-downs of the wind-chest, however wide apart they may be. This action is suitable for both single and divided wind-chests, as well as for any system of pipe arrangement.

When it is necessary to carry the action in a direct line from the keys to some distant part of the Organ, squares are employed instead of backfalls. These require to be inverted so as to obtain a pulling motion, and may be connected with the keys by short stickers, as shown in Diagram 2, Fig. CXLII., or by direct contact, as indicated in Diagram 4. Horizontal trackers extend from the lower arms of the squares to any distance required. The ends of these are shown at D in the diagrams. The other ends of these trackers are connected with inverted squares, which convert the horizontal to a vertical pulling motion. Vertical trackers carry this motion to a roller-board placed directly under the pull-downs of the wind-chest, where the pulling motion is distributed in the manner already described. This kind of tracker action has been frequently used for Church Organs of moderate dimensions, where it has been sometimes applied to each of the three manual claviers, the horizontal trackers being carried parallel to each other and as close together as practicable. The series of trackers from each clavier will be of the necessary length to reach the squares and vertical trackers of the wind-chest it commands. The different series will accordingly be of widely different lengths. When two or three series of trackers are carried in the manner just alluded to, a coupling action may be associated with them, operating from one series to another. A three manual tracker action of this kind, including two couplers operating between the different series of horizontal trackers, is to be seen in the Organ of Aigburth Church, near Liverpool.*

Although simple, or unaided, tracker actions have been constructed, in which horizontal trackers of great length have been used, as in the case of divided Organs, played from consoles placed somewhere between their two sections; and although great mechanical skill has been displayed in their formation, so as to secure a practical key touch, it is not too much to say that no English or American organ builder of to-day, with pneumatic and electric actions at his disposal, would contemplate for a moment inserting such tracker actions.

In numerous modern Organs of important dimensions the unaided tracker action has been employed for the Choir and Swell divisions, while the pneumatic lever has been confined to the Great division and all couplers connected therewith. This arrangement was devised with the special view of relieving the key touch of the greatly increased weight caused by the coupling of two or more divisions. When the pneumatic lever action is used, every endeavor is made to place the series of levers as close to the keys as possible, so as to secure a very simple tracker movement between the key tails and the valves of the levers, but in very large Organs it has been found necessary to locate the series of levers belonging to certain divisions at considerable distances from the claviers, entailing very long tracker movements between them. For instance in the Grand Organ, constructed by Cavaillé-Coll, in the Church of Saint-Sulpice, at Paris, we find three

* It is many years since we examined this Organ while in course of erection; but we presume it is still in existence.

tracker movements directly connected with the Third, Fourth, and Fifth Claviers, and extending about forty feet in length between them and their respective series of pneumatic levers. These movements require each no fewer than six squares and seven distinct lengths of tracker to every key. Coupling backfalls, operated by the pneumatic levers belonging to the First Clavier, act on studs fixed on the main vertical lengths of these trackers. Tracker movements of so great a length are most undesirable ; and nothing but perfect workmanship and adjustment can render them practicable.

In a long tracker action, in addition to every expedient being devised to eliminate avoidable friction, proper attention should be paid to the balance of its moving parts, so that no difficulty in overcoming the inertia of the long trackers, rollers, and other movable parts, may be experienced by the performer at the keys. The action should have no sluggishness while being set in motion by the depression of the keys, or in returning to a state of rest on the release of the same. There is a practical difficulty, in a tracker action of even moderate length, in securing the same weight and peculiarity of touch on each and every key ; yet every expedient ingenuity can devise must be resorted to by the organ builder to overcome this difficulty. Nothing, perhaps, is more objectionable to the performer than a pronounced inequality or irregularity in the touch of the manual keys of any one division of the Organ. Extreme care, from the selection of the materials for the action to the minutest final adjustment of the movement, can alone secure the desirable result. Such care involves considerable time—a commodity the average organ builder is never lavish of, and for the expenditure of which he is rarely if ever properly remunerated. Such will always be the case until organ-building is elevated to its proper place in the arts, and is practiced only by true artists, who will demand and receive adequate remuneration for their time and skill. But it is well to remark, after the words just used, that elaborate tracker actions are almost things of the past, and that the artist in organ-building has a better field for the expenditure of his time and skill.

While tracker actions have been generally used in conjunction with the old-fashioned, palleted wind-chest, they have occasionally been successfully introduced in modern Organs, in which the wind-chests are constructed with a pneumatic pallet to every pipe or note of every stop planted thereon. In the former case the action connected with each key has to overcome a more or less powerful pallet-spring plus the considerable pressure of the condensed organ wind on the under surface of the pallet : while in the latter case the action has so little to do in operating the small and light controlling valve belonging to each note, that it has to be weighted or fitted with a spring just sufficient to return it on the release of the key. Almost any desirable degree of lightness can be given to this tracker action, allowing that it is properly made and carefully balanced in itself.

As all the component parts of the tracker action have been fully described and illustrated, and their usual combinations outlined, it is unnecessary to go farther into the subject. All matters connected with the claviers, pneumatic levers, and wind-chests, between which the tracker action extends, are treated of at length in the Chapters devoted to them.

CHAPTER XXIV.

THE SLIDER AND PALLET WIND-CHEST.

THE Wind-chest is that portion of the Organ on which the pipes are planted, and by means of which the compressed air from the bellows is systematically supplied to the pipe-work through the agency of the mechanical parts of its construction which are commanded by the key and draw-stop actions of the instrument.*

English organ builders and writers on organ-building have illogically and incorrectly designated this portion of the Organ the "soundboard," applying the term wind-chest to only a subordinate part thereof. It is somewhat difficult to account for the adoption, and still more for the retention, of so inappropriate a name; for it would not be possible to devise anything, constructed of wood, more incapable of sound-production or sympathetic vibration. There is no analogy whatever between the wind-chest, or so-called soundboard, of the Organ and the true soundboard of the pianoforte and other stringed instruments, which is "a thin resonant plate of wood so placed as to enhance the power and quality of the tones by sympathetic vibration." Such being the case, we have not, outside the present remarks, used the term "soundboard" in our pages. English organ builders apply the term "wind-chest" to the portion of the so-called soundboard which immediately incloses the pallets. As this chamber is charged with compressed air, direct from the bellows or wind reservoir, ready to supply the pipe-work, the name is quite appropriate; but, as it is highly desirable to get rid of the illogical term soundboard, and use the term wind-chest for the entire construction, this adjunct may be still more appropriately designated the pallet-box.

It is quite safe to say that no part of the Organ has been the object of so much study and inventive skill as the wind-chest; and, considering its great im-

* "WIND-CHEST. In *organ-building*, a chest or box immediately below the pipes or reeds, from which the compressed air is admitted to them by means of valves or pallets."—"The Century Dictionary."

portance in the economy of the instrument, this is not to be wondered at. The desirable conditions which have presented themselves to every designer of a wind-chest, from the earliest times of legitimate organ-building up to the present day, are ones that even in the latest and most improved wind-chests are not fully met. It is extremely difficult to have every detail absolutely satisfactory, for it has been found, from practical experience, that perfection in one direction is unfortunately accompanied by some imperfection in another. This may be accepted as a general rule in organ-building, and in no branch is it more marked than in that of wind-chest construction. Before attempting to describe the several representative forms of the wind-chest that have been introduced by different organ builders, we may outline the conditions necessary for the production of a satisfactory one. These may be correctly designated the Ten Commandments of wind-chest construction.

I. The upper surface of the wind-chest must be of ample dimensions, so that all the pipes planted thereon may have sufficient room to speak properly, and be so planted as to be conveniently reached for regulating, tuning, etc.

II. Absolute stability in its construction; so that the wind-chest may withstand the heavy load of the pipe-work placed upon it.

III. The greatest possible simplicity of construction; so that liability to derangement may be minimized, and repairs be executed with ease and expedition without disarranging other portions of the Organ.

IV. A copious wind supply to all the pipes, under all conditions, and at an absolutely uniform pressure at all times; so that the pipes shall yield their proper tones and remain at their true pitch.

V. A separate wind supply to all the stops; so that however many stops may be drawn, and however many pipes may be speaking, there shall be no diminution in the pressure, or robbing of the condensed air furnished to the pipe-work.

VI. That there shall be no leakage or loss of wind through any of the mechanical devices introduced in the wind-chest, when the stops are drawn, and whether pipes are sounding or not.

VII. That the pallets or valves shall be so constructed and located in the wind-chest as to remain free at all times from the accumulation of any deposit liable to interfere with their proper closing.

VIII. That all the mechanical devices comprised in the wind-chest shall be of the simplest character and the least liable to go out of order; so that reasonable durability may be calculated upon.

IX. That all the moving parts of the wind-chest shall be certain, prompt, and silent in their action.

X. That every precaution shall be taken to protect the wind-chest against the action of damp air and the extremes of temperature.

While these ten conditions of excellence do not admit of any reasonable question, it must be said that very few wind-chests at present introduced meet them all in a state approaching perfection.

Respecting the forms and modes of constructing the earliest wind-chests no satisfactory information has been handed down; but they probably did not differ

essentially from the simple arrangement described, after a fashion, by Theophilus in the third book of his "De Diversis Artibus," written in the eleventh century.* Marcus Vitruvius Pollio, who appears to have written about 25 B. C., describes in a somewhat vague manner—a manner unfortunately common in ancient authors—the construction of a wind-chest, which, in its general characteristics, seems to resemble the later one outlined by Theophilus. He says: "On the neck a chest, framed together, sustains the head of the instrument, which in Greek is called κανὼν μουσικὸς (canon musicus); upon which, lengthwise, are channels, four in number if the instrument be tetrachordal, six if hexachordal, and eight if octochordal. In each channel are fixed stops, that are connected with iron finger-boards; on pressing down which, the communication between the chest and the channels is opened. Along the channels is a range of holes corresponding with others on an upper table called πίναξ in Greek. Between this table and the canon, rules are interposed, with corresponding holes, well oiled so that they may be easily pushed up and return; they are called *pleuritides*, and are for the purpose of stopping and opening the holes along the channels, which they do by passing backwards and forwards. These rules have iron jacks attached to them, and being united to the keys, when those are touched they move the rules. Over the table there are holes through which the wind passes into the pipes. . . Hence, when the keys are touched by hand they propel and repel the rules, alternately stopping and opening the holes, and producing a varied melody founded upon the rules of music." †

Still earlier in date, we have the description given by Hero, of Alexandria,

* In the Chapter on The Organ Historically Considered (Vol. i., p. 24) we have quoted the translation by Robert Hendrie of the description given by Theophilus in his chapter entitled "De Domo Organaria." For the satisfaction of Latin scholars we here give the original Latin text.

De Domo Organaria—Domus vero facturus super quam statuendæ sint fistulæ, vide utrum volueris eam ligneam habere aut cupream. Si ligneam, acquire tibi duo ligna de platano, valde sicca, longitudine duorum pedum et dimidii, et latitudine modicè amplius quam unius, unum quatuor, alterum duobus digitis spissum, quæ non sint nodosa sed pura. Quibus diligentissimè sibi conjunctis, in inferiori parte spissioris ligni fiat in medio foramen quadrangulum, amplitudinè quatuor digitorum et circa quod reliquantur de eodem ligno limbus, unius digiti latitudinis et altitudinis, in quo conflatorium inponatur. In superiori parte verò lateris fiant cavaturæ, per quas flatus ad fistulas possit pervenire. Altera vero pars ligni, quæ et superiori esse debet, metiatur interius æqualiter, ubi disponantur septem vel octo cavaturæ, in quibus diligenter jungantur linguæ, ita ut habeant facilem cursum educendi et reducendi, sic tamen ut nichil spiraminis inter juncturas exeat.

In superiori autem parte tonde cavaturæ, contra inferiores, quæ sint aliquantulum latiores, in quibus jungantur totidem ligna, ita ut inter hæc et majus, ligni cavatura remaneat vacua, per ventus ascendat ad fistulas, nam in eisdem lignis foramina fieri debent, in quibus fistulæ stabiliendæ sunt. Cavaturæ in quibus linguæ junctæ sunt in anteriori parte, procedere debeant quasi obliquæ fenestræ, per quas ipsæ linguæ introducantur et extrahantur.

In posteriori vero parte, sub fine ipsarum linguarum, fiant foramina æqualiter lata et longa, mensura duorum digitorum, per quas ventus possit ascendere ab inferioribus ad superiora, ita ut cum linguæ impinguntur, illa foramina ab eis obstruantur, cum vero trahuntur denuò pateant. In his vero lignis quæ super linguas junguntur fiant foramina diligenter et ordinatè, secundum numerum fistularum, uniuscujusque toni, in quibus ipsæ fistulæ imponantur, ita ut firmiter stent, et ab inferioribus ventum suscipiant. In caudis autem linguarum scribantur litteræ secundum ascensum et descensum, cantus quibus possit cognosci quis ille, vel ille tonus sit. In singulis autem linguis fiant foramina singula gracilia, longitudinè dimidii digiti minoris, in anteriore parte, juxta caudas in longitudine, in quibus ponantur singuli clavi cuprei capitati, qui pertranseant in medio fenestallas, quibus inducuntur ipsæ linguæ a superiori latere domus usque ad inferius, et appareant clavorum capita superius ita, ut cum linguæ cantantibus organis educuntur, non penitus extrahantur. His ita dispositis conglutinentur hæc duo ligna, quæ domum organorum conficiunt glutine casei; deinde partes illæ quæ super linguas sunt junctæ, in quibus foramina stant, sicque circumcidantur diligenter et radantur.

† Translated from the Latin by Joseph Gwilt, F. S. A., F. R. A. S.

who lived sometime in the third century B. C. In his treatise on Pneumatics we find the following passage alluding to the wind-chest of an Organ, and the mechanism employed to admit and cut off the compressed air to and from the speaking pipes.

"In order that, when we wish any of the pipes to sound, the corresponding holes may be opened and closed again when we wish the sound to cease, we may employ the following contrivances: Imagine one of the boxes at the extremities of the pipes C D, to be isolated, D being its orifice, E the communicating pipe, R S the lid fitted to it, and G the hole in the lid, not coinciding with the pipe E. Take three joined bars, F H, M M, M M^2, of which the bar F H is attached to the lid S F, while the whole moves about a pin at M^3. Now, if we depress with the hand the extremity M^2 towards D, the orifice of the box, we shall push the lid inwards, and when it is in, the aperture in it will coincide with that in the tube. That when we withdraw the hand, the lid may be spontaneously drawn out and close the communication, the following means may be employed. Underneath the boxes let a rod, M^4 M^5, run equal and parallel to the tube A B, and fix to this slips of horn, elastic and curved, of which M^6, lying opposite C D, is one. A string fastened to the extremity of the slip of horn is carried round the extremity H, so that when the lid is pushed out, the string is tightened, if, therefore, we depress the extremity M^2, and drive the lid inwards, the string will forcibly pull the piece of horn and straighten it; but when the hand is withdrawn, the horn will return again to its original position and draw away the lid from the orifice, so as to destroy the correspondence between the holes. This contrivance having been applied to the box of each pipe, when we require any of the pipes to sound, we must depress the corresponding key with the fingers, and when we require any of the sounds to cease, remove the fingers, whereupon the lids will be drawn out, and the pipes will cease to sound." *

It is to be regretted that the drawing made by Hero for his treatise, to which the letters in the above description referred, has not been preserved. Different translators have attempted to supply the want; but of course their imaginative renderings are practically valueless. From the description alone we can gather that the wind-chest resembled those described by Vitruvius and Theophilus, inasmuch that it consisted of a box or wind-chamber and an upper portion or table on which the pipes were planted, between which were fitted sliders perforated with holes corresponding with the holes which were bored through the top of the wind-chamber and the table on which the pipes stood. These sliders served the same purpose as do the pallets or valves in the modern wind-chest. When the sliders were in the position that brought their perforations directly opposite and between the holes in the wind-chamber and the pipe table, the compressed air had access to the pipes, but when they were moved either in one direction or the other the compressed air was cut off from the pipes. The sliders appear to have been in some cases moved directly by means of handles attached to them; while in others they were manipulated through the agency of a sort of recovering lever action, as

* From "The Pneumatics of Hero of Alexandria," by Bennet Woodcroft.

described by Hero. In a miniature in the eleventh century Bible of Saint Étienne Harding, of Dijon, an Organ is represented having eight sliders furnished with handles, two of which are drawn out by the performer.* The construction here shown substantially agrees with that described by Theophilus, as will be seen on referring to the translation of his chapter on "the Organ Erection," given in our Chapter on the Organ Historically Considered.

So long as the Organ remained about an octave in compass, and its pipes formed a species of MIXTURE of two, three, or more ranks, the simple slider wind-chest did not call imperatively for radical change; at all events we find it recorded in this condition in the eleventh century. At what time this primitive wind-chest with manual sliders, as above described, gave place to the wind-chest furnished with pallets connected with a key action, and longitudinal sliders commanding the several ranks of pipes, no authentic information is forthcoming; but in all probability the change took place when the advisability presented itself of separating the several ranks of pipes of different pitches, so as to enable the performer to use them in varied combinations at will. We can only imagine what the wind-chests of such Organs as those of Halberstadt and Magdeburg were like, seeing that the manual keys of these old instruments were such colossal affairs as to require the application of the closed fists in no measured fashion. Copies of the drawings of these keys given by Prætorius are inserted in our Chapter on the Manual Claviers. It is quite reasonable to suppose that the wind-chests of these instruments were as clumsy as the claviers which commanded them: it is even probable that they were slider (in the ancient fashion above described) and not pallet wind-chests; for it is difficult to imagine any pallet action that would require so robust a style of playing.

We may now briefly touch upon the pallet wind-chest as it appears in the Organs of the eighteenth century, the construction of which is so fully and admirably illustrated by Dom Bedos in "L'Art du Facteur d'Orgues."† In general form and construction it differs but slightly from the pallet and slider wind-chest of to-day, while it is evident that much greater care was bestowed on its formation than is evidenced in modern examples. The bars forming the grooves or wind-channels are securely glued into sinkings cut in the front and back cheeks of the chest, and the end pieces are tenoned into mortises in the ends of the cheeks. The table on which the stop sliders rest is formed of narrow pieces of hardwood, well glued to the cheeks, ends, and bars, being jointed and securely pinned immediately where the bearers come. The upper surface is planed perfectly level and subsequently covered with smooth leather of uniform thickness, upon which the bearers rest and the sliders move. The under side of the chest which extends beyond the pallet-box is covered with vellum or leather, securely glued to the wood-work and closing all the grooves. The pallet-box and pallets do not differ in any essentials from the same parts in the modern wind-chest; but the pull-downs, which are attached to the pallets, pass through leather purses instead of through holes

* A copy of this miniature is given in "Étude sur l'emploi des clochettes chez les anciens," by Abbé Morillot.

† Plates XXXIV., XXXV., XXXVI., XXXVII., XXXVIII., LV., and LVI.

in brass plates, practically air-tight, as in later work. The bearers, sliders, and upper-boards are similar to those found in the best modern examples of the class. The upper-boards are made of the proper widths to suit the requirements of the several stops, and come together and are fastened down over the bearers. It is unnecessary to illustrate anything connected with this old wind-chest save the pull-down and its leather purse, which are shown, in section, in the accompanying illustration, Fig. CL. A is a cylindrical wood rod, in two lengths, through which

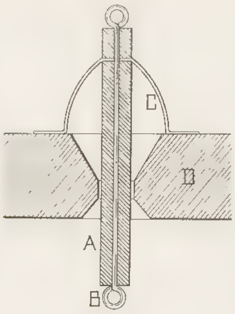


FIG. CL.

passes the pull-down wire, B; and C is the leather purse, held air-tight between the two lengths of the rod, A, and glued around its flange to the bottom board of the pallet-box, D. The upper eye of the wire is linked to the pallet, while the lower eye is attached to the key action. The purse is formed of leather, which has been pressed into a mould while wet and allowed to dry, its flat rim or flange being subsequently trimmed round. The center of the purse is perforated for the passage of the pull-down wire, and is held firmly between the two lengths of the wooden rod A, which are pressed together by the two eyes of the wire. The entire wind-chest, in the old Organs, was almost invariably constructed of perfectly seasoned and straight-grained oak, as mentioned by Seidel and other writers. This durable wood was a favorite with the old builders for all the important parts of the Organ, including much of the wood pipe-work.

Having briefly traced the wind-chest from its practical inception to the state it assumed in the eighteenth century, we may now describe its mode of construction in England prior to the introduction of the sliderless wind-chest, and the tubular-pneumatic and electro-pneumatic actions.

The pallet and slider wind-chest comprises two important divisions; the larger of which may be designated the wind-chest proper, and the smaller division the pallet-box. Both divisions are formed of several parts which are known by different names. The wind-chest proper consists of the frame, the table, the sliders and bearers, the upper-boards, and the rack-boards; while the pallet-box comprises the box, the pallets, the pallet-springs, and the pull-downs. There remain some minor parts which are mentioned farther on. Both skill and care are

required in the construction and adjustment of all the above-named parts; for much of the excellence of the finished Organ depends upon the manner in which the wind-chests are planned and made. If inferior or unsuitable materials are used, or if the parts are carelessly or unskilfully put together, endless annoyance will result, and defects will soon show themselves which cannot fail to seriously impair the utility and beauty of the instrument.

The first step to be taken in the construction of a wind-chest is the preparation of a full size plan thereof, showing the position of every pipe, the widths and exact positions of the sliders and bearers, the divisions of the upper-boards, and the widths of the transverse grooves and bars of the frame. This plan may be drawn on thick paper, or on a clean white pine board, ⅝ inch thick, jointed up, and dressed. Under ordinary conditions this board may subsequently be used for the rack-boards of the finished wind-chest, being cleanly planed over, separated into the requisite number of widths to correspond with the upper-boards, bored for the pipe feet, rack-pillars, etc., and varnished. As wind-chests vary greatly in their dimensions and in the disposition of their pipe-work, only general hints can be here given for their planning. The most important matter is to scheme the wind-chest of ample length and width, so that all the pipes to be planted thereon may have the desirable amount of speaking room. No pipe should have less than its own width or diameter in front of it to speak into, and this minimum should be exceeded in all possible cases. The value of a spacious wind-chest, whatever its nature may be, and of open planting of the stops or ranks of pipes cannot be overrated. It is impossible to obtain a satisfactory tonal result with a small and overcrowded wind-chest. This fact should be borne in mind by those who desire to cram an Organ of many stops into a space much too small for its accommodation. The difficulty of providing ample speaking room is only met with in planting the pipes of the bass and tenor octaves, for the treble pipes have, in all properly planned wind-chests, superabundance of room. Experience has shown that there are some classes of pipes that require less speaking room than others. As a general rule, pipes of small and medium scales, the tones of which are rich in harmonics, require more space, in proportion to their diameters, in front of their mouths than do the larger-scaled flute-toned pipes. This latter fact is supported by the behavior of BOURDON pipes, which have been found to speak best when somewhat closely placed, providing their mouths were not directly opposite the mouths of other pipes. A good deal can be done toward securing satisfactory results by a proper arrangement of the stops, care being taken to keep those of the same pitch, which are likely to sympathize with each other, apart by placing between them one or two stops of a decidedly unsympathetic character. Experience can alone guide the wind-chest designer in these important matters.

When the drawing-board or properly stretched paper is provided, and the proposed dimensions of the wind-chest are marked thereon, the transverse lines indicating the bars and grooves of the frame and the longitudinal lines indicating the positions and widths of the sliders are accurately drawn. Within the boundary lines of the sliders, and in the centers of the grooves, marks are made indicating where the holes are to be bored in the upper-boards and through the sliders and

table for the passage of the compressed air from the grooves to the feet of the pipes. When the planning is carried so far, what is known as the planting is proceeded with. This is done by means of zinc or paper patterns, which represent the exact forms and dimensions of the transverse sections of the pipes. These patterns are carefully arranged to the best advantage on the plan, and their outlines drawn thereon and the centers of the pipe feet pricked through and distinctly marked. In all possible cases the pipes are so placed as to stand directly over their wind; and when that is not possible, every care is taken to plant them as close to their wind supply as practicable. There is of course no difficulty experienced in planting all the pipes of the treble octaves, and, accordingly, it is rarely necessary to use the patterns above middle c^1, except, perhaps, in the case of a large-scaled stop of 16 ft. pitch, such as a BOURDON or a LIEBLICHGEDECKT. It is frequently found impossible to find room for the larger pipes of the bass octaves of certain stops directly on the wind-chest: these are, accordingly, planted on detached speaking-blocks, to which the compressed air is carried from the upper-boards by means of metal conveyances.

Before describing the construction of a representative slider wind-chest, it is desirable to mention the different arrangements of the pipes commonly met with in Organs.

The first arrangement, suitable for small instruments, places the lower twenty notes of the bass and tenor octaves alternately at each end of the wind-chest, all the remaining pipes, above tenor G, being planted semitonally in their proper order. This arrangement has the advantage of distributing the weight of the larger pipes almost equally on the wind-chest.

The second arrangement, which belongs to the so-called "simplification system," and which is suitable for single wind-chests that are disposed transversely, or end on, in an Organ, places all the pipes, from the lowest to the highest notes, semitonally in their proper order, the treble pipes being toward the front of the instrument, so as to offer no obstruction to the free egress of sound. This arrangement is not to be recommended for wind-chests placed longitudinally, notwithstanding the fact that it prevents the necessity of crossing the key action.

The third arrangement, which may be adopted for single or divided wind-chests, places the lowest bass pipes in the center, and all the other pipes above CC♯ alternately and tonally on each side, the higher treble pipes occupying the ends of the wind-chest. This arrangement has sometimes been employed for Swell Organs of moderate dimensions, which could be most conveniently tuned from the ends of the swell-boxes and without disturbing the louvres in front.

The fourth arrangement is that which should always be adopted for large divided wind-chests, whether open or inclosed, the wind-chests being separated by a passage-board for tuning, etc. In this arrangement the CC pipes are placed at the outside end of the left wind-chest, and the CC♯ pipes at the outside end of the right wind-chest; from these the pipes are planted tonally on each chest, the higher treble pipes adjoining the dividing passage-board. This system of planting is acoustically favorable, and it admits of convenient access to every pipe for tuning and regulating.

The principal part of the wind-chest proper is the frame, including the table on which it is built. The frame is formed of numerous transverse and parallel bars of wood, between which are grooves or channels for the conveyance of the compressed air from the pallet-box to the pipes of the several stops planted on the upper-boards. When the dimensions of the wind-chest and the sizes and positions of the bars have been decided by the general plan, as before mentioned, the frame is formed in the following manner: The bars are carefully planed to their correct thicknesses and their edges dressed true and square, and then cut to about 1/8 inch longer than their finished length. In addition to the bars, pieces of wood, called fillings-in, have to be provided: these are of the same depth as the bars, and of the exact widths of the grooves or spaces to be left between the bars. The fillings-in are carefully cross-cut, with a fine saw, from three pieces of dressed wood, about 5/8 inch thick, held together so as to secure absolute accuracy. Each set of three pieces is kept separate, and placed in the progressive order of the grooves, ready for use. The next thing to prepare is the table. This is formed of straight-grained mahogany, about 1/2 inch thick, securely jointed (the joints falling in the center of the bearers subsequently attached to the upper surface of the table), and carefully dressed flat and gone over on one side with a toothing-plane. The table, which is made somewhat larger than its finished dimensions, is laid, with its toothed surface uppermost, on a rigid, level surface prepared for the purpose, and firmly secured to the same by screws or clamps. Lines indicating the positions of the bars are now scratched across the table; and single lines are marked longitudinally to guide the adjustment of the ends of the bars and the fillings-in. In addition to the ordinary bars, which form the majority of the grooves, double or screw bars are introduced at intervals in the length of the frame. These may vary in thickness from 1 1/4 to 2 inches. End cheeks, about 2 inches thick, are also required. When all the woodwork is ready, the gluing or building-up is proceeded with. Two men are required for this process. A good coating of very hot glue is spread across one end of the table, and on it is laid a cheek, in proper position, and firmly clamped down. To the inside face of the cheek, and resting on the table, are now glued the first pair of fillings-in—one at each end. The necessary portion of the table and the exposed edges of the fillings-in are now well covered with glue, and the first bar is pressed in position against them. The second pair of fillings-in and the second bar are glued in position in the same manner; and the process is repeated until all the bars and the remaining end cheek are glued to the table. During this building-up process, the remaining pieces of wood, cut along with the fillings-in, are glued in flatwise between the bars and flush with their exposed edges, forming a continuous surface throughout the length of the frame, and at a proper distance from one of its sides, for the reception of the leather hinges or the tail pins of the pallets, and also the back or wind-bar of the pallet-box. The above description will be clearly understood on referring to the diagrams given in Fig. CLI. The upper diagram is a Transverse Section of the frame, cut through a groove. A is the table; B is a bar; C is the filling-in at the pallet side and D the filling-in at the closed side of the frame; and E is the piece inserted to receive the pallet hinge and the so-called

wind-bar. The middle diagram is the Plan of one end of the frame. A is the table projecting slightly beyond the frame; B B B B are four of the bars; C and D are the front and back fillings-in; and F is the end cheek first glued to the table. As this Plan shows a portion of the frame above which bass pipes will ultimately stand, the grooves for conveying the compressed air (filled in black) are widely separated by two bars having a space or false groove between them. Two bars are here introduced to avoid the necessity of using a single very thick bar. Single bars are introduced when the distances between the grooves do not exceed 1½ inches. The screw bars are usually about 1⅜ inches thick in the treble portion of the frame, and may be placed at any distance apart deemed desirable. The practice of different organ builders varies in all such matters.

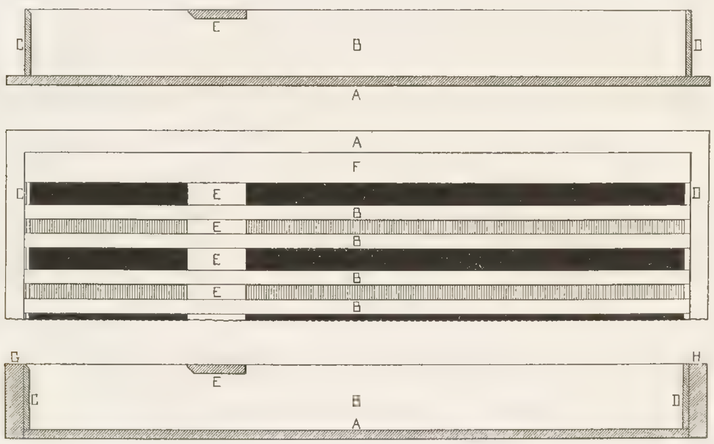


Fig. CLI.

When the frame has become perfectly dry, the excess of the table is removed, and the ends of the cheeks and bars and the fillings-in are dressed perfectly flat, and the surfaces so prepared are well sized with thin glue to check the absorption of the exposed end wood. The frame is finished, so far as its structure is concerned, by having side cheeks of mahogany or oak, about 1¼ inches thick, glued to the sized surfaces above described. The lower diagram given in Fig. CLI. is a Transverse Section of the frame, showing the addition of the side cheeks G and H. The exposed edges of the bars, side and end cheeks, etc., are now carefully planed smooth and level, ready to receive the pallet-box, pallets, and external air-tight covering. This portion of the wind-chest is practically finished when the external faces of the cheeks are dressed and the table is planed to a smooth and perfectly level surface and cross channeled to receive the bearers and sliders.

The accompanying illustration, Fig. CLII., shows the disposition of the bars

and grooves of a wind-chest frame, according to the first arrangement previously described. In the Plan all the bars, fillings-in, and the end and side cheeks, are indicated; but the bridging-pieces for the reception of the pallet hinges, etc. (shown at E in Fig. CLI.), are omitted. The solid black parts indicate the wind-grooves which convey the compressed air to the pipes. To avoid the necessity of using several very thick bars in the bass octave, where the wind-grooves have to be kept widely apart, pairs of comparatively thin bars are inserted with false grooves between them. The false grooves, which are left white, are indicated by the fillings-in at each of their ends. The Longitudinal Section, which accompanies the Plan, further explains the construction of the frame.

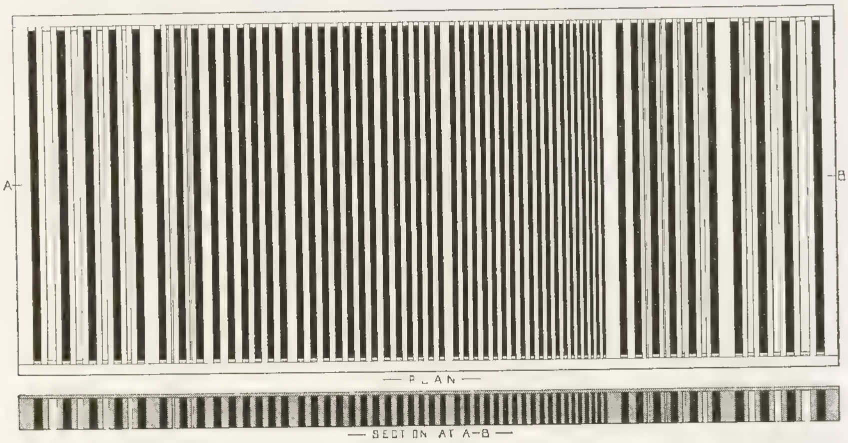


FIG. CLII.

Before we leave the consideration of this portion of the wind-chest we may describe and illustrate the remaining three arrangements of the wind-grooves, adapted to the corresponding modes of planting the pipes. In Fig. CLIII. are given three Longitudinal Sections illustrating these arrangements. The upper Section shows the disposition of the grooves according to the second arrangement which accompanies the semitonal planting of the pipes as dictated by the so-called simplification system. From the Section it will be seen that the grooves extend in regular order from the lowest bass note to the highest note of the manual compass. The lower Section shows the disposition of the grooves according to the third arrangement. In this the grooves for the CC and CC♯ pipes occupy positions adjoining the center of the frame, while the other grooves extend, in tonal progression, toward the ends of the frame. The middle Section illustrates the fourth arrangement, which calls for divided wind-chests, so placed that the treble notes occupy positions toward a central passage-board, as previously described.

The frame having been completed and the table planed in the manner above described, the formation of the bearers and sliders, which rest on the surface of the table, next claim consideration. The bearers and sliders are pieces of thoroughly seasoned and straight-grained mahogany, accurately dressed to a uniform thickness—about 3/8 inch for large wind-chests—and to the several widths set out on the general plan. The bearers, which support the upper-boards at the proper distance above the surface of the table and act as guides to the sliders, are cut to the exact length of the table, while the sliders, which move between the bearers, are made a few inches longer than the table to admit of their being connected with the draw-stop action. To reduce friction and to prevent any objectionable running of the wind, the bearers should have their edges, next the table, splayed slightly; or the table may be channeled longitudinally under the edges of the bearers to prevent the running of the wind, save in a safe direction. The bearers are secured to the table by means of small brass screws or hardwood pins. The sliders are now laid in position, and temporarily held by small pegs at their ends. Should any inequalities be found in the thicknesses of the sliders and bearers, they should be carefully removed with a fine plane. It is essential that everything connected with this portion of the wind-chest should be finished with absolute accuracy.

The upper-boards have now to be prepared. These are either solid or built-up planks, of different thicknesses, according to the requirements of the stops to be planted on them, and of the length required by the plan. A separate upper-board should be provided for each stop; but in the case of small wind-chests this desirable practice is not always followed. The boards are made of sufficient width to extend to the center lines of the bearers on each side of their respective sliders. The outside boards may, if necessary, extend slightly beyond the front and back cheeks of the frame below. When solid upper-

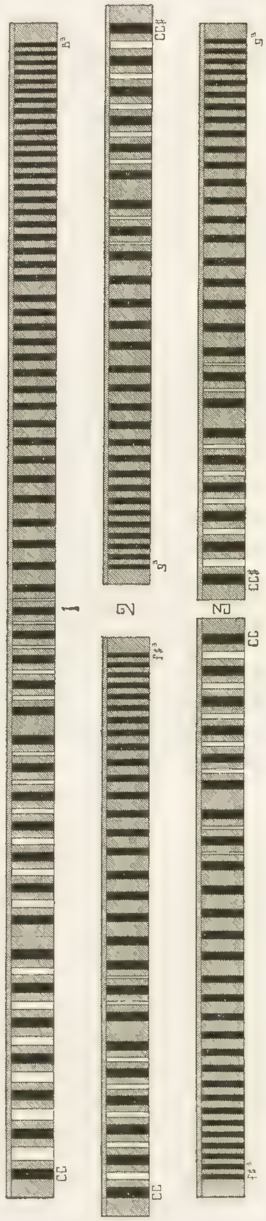


Fig. CLIII.

boards are used they should be made of clean, straight-grained, and thoroughly seasoned bay-wood, about 1½ inches thick. No wood at all liable to warp should be used. Any grooving necessary in such boards, after being carefully and smoothly cut, should be covered by a mahogany veneer, ⅜ inch thick, either permanently glued to the upper surface of the boards, or covered with leather and tightly screwed down. Upper-boards subjected to extreme atmospheric changes should be built up of two layers of straight-grained mahogany, ⅜ inch thick, glued on a center layer of clear white pine, ¾ or 1 inch thick. This construction reduces the liability to warp to a minimum: it also allows any necessary grooving to be done in any board, by cutting the grooves through the pine layer before the outside layers of mahogany are glued on. In the case of a grooved board of this class, the three layers are pinned together in proper position during the process of being marked and bored for the rack-pillars, screws, and pipe-feet, and for communication, through the slider and table, with the wind-grooves of the frame below. When all the boring and grooving are completed the three layers are glued together, the pins holding them correctly in their relative positions.

The upper-board for the reception of a compound harmonic-corroborating stop has to be constructed in a special manner; for while its under part is pierced with single holes, corresponding with those through the slider and table, its upper part has to be pierced with groups of holes for the reception of the feet of the several ranks of pipes. There are different modes of forming this upper-board. In its simplest form, suitable for the reception of a three-rank MIXTURE, all the pipes of which can be planted in straight, transverse rows, the upper-board may consist of a solid or built-up plank, about 1¾ inches thick, having holes bored from one edge, transversely, and nearly through its width, each hole being directly over a corresponding wind-groove in the frame. Single holes, exactly coinciding with the wind holes in the slider and table, are bored from the under side of the board into the long transverse perforations or channels; and smaller holes, for the reception of the feet of the pipes, are bored from the upper side of the board down into the same transverse channels. The transverse channels are either plugged with wood along the edge of the board, or the entire edge is covered with a strip of leather or oil-cloth, securely glued on. This mode of construction, which appears to have been commonly adopted by the old German organ builders, is illustrated in Diagram 1, Fig. CLIV. The transverse channel A is bored in a solid plank; B is the hole through which the compressed air enters the channel; and at C are the countersunk holes for the reception of the feet of the pipes. By this simple arrangement the compressed air from the wind-grooves below, passing up through the openings in the table, slider, and the lower part of the upper-board into the transverse channels, finds its way through the upper holes to the feet of the pipes.

When the ranks are numerous, and the space available for the stop on the wind-chest prevents the pipes being planted, throughout the compass, in straight, transverse rows, a different mode of construction becomes necessary. The upper board may be formed of two layers or veneers of mahogany, about ⅜ inch thick, having a middle layer of perfectly clean white pine, or bay-wood if preferred,

about 1 inch thick. While the under veneer is perforated with holes corresponding with those in the slider and table, and the upper veneer is perforated for the reception of the feet of the several ranks of pipes, grouped in the most compact manner, the middle layer of pine or bay-wood is perforated in such a manner as to embrace all the holes belonging to each note of the compass, in succession. Each perforation, whatever its form may be, can be readily cut out with a fret-saw, starting from a center-bit hole. The veneers are then glued to the middle layer, their correct positions being determined by adjusting pins. This mode of construction is illustrated in Diagram 2, which, for the sake of distinctness, is shown with straight, transverse perforations, as at D, suitable for a three-rank MIXTURE.

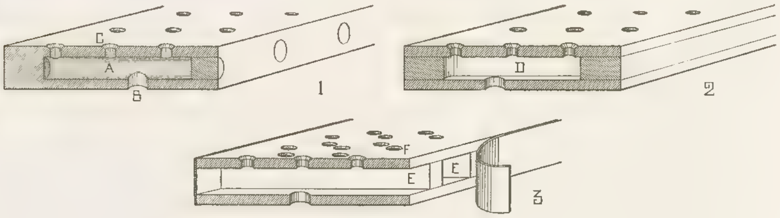


FIG. CLIV.

Another mode of construction may be followed. The upper and under veneers of mahogany, perforated for the entrance of the compressed air and for its egress to the pipe work, are provided as previously described. Then, instead of the middle layer of pine, thin pieces, cut from the end of a plank 1 inch thick and slightly wider than the veneers, are glued transversely on the under side of the upper veneer, between each group of pipe holes; and larger end pieces are added which have been previously adjusted to both the veneers and furnished with guiding pins. The under veneer is subsequently glued to the ends and all the intermediate transverse pieces. The upper-board is practically completed by having its edges planed straight and covered with strips of leather or some durable, air-tight material, closing all the grooves or air chambers formed between the veneers. Diagram 3 illustrates this last mode of construction. The transverse pieces or partitions are shown at E, glued between the upper and under veneers. The chambers are closed at both ends by strips of leather, as indicated. The holes for five ranks of pipes are shown at F. Certain modifications of the modes of construction above described are followed by different builders.

We must now return to the stage in the construction of the wind-chest preparatory to the application of the upper-boards. The ordinary upper-boards, and the layers or veneers (unglued, and simply held together by guiding pins) of those required for the compound stops, are now taken and bored at proper intervals, near their edges, for the screws that are to hold them firmly down upon the bearers, and which are to pass through corresponding holes in the bearers into the solid wood of the screw bars of the frame below. The upper-boards are all placed accurately

in position over the sliders and bearers, and firmly screwed down. The pine board, previously described, on the upper surface of which are accurately marked the positions of all the perforations to be made in the table, sliders, and upper-boards, and the holes for the rack-pillars, pipe feet, etc., is now laid on the upper-boards and temporarily secured to the same by a few small screws or wire nails. The holes for the rack-pillars are bored through the pine board (which will ultimately form the rack-boards) and into the solid upper-boards to the depth of about ⅞ inch; while in the case of the boards which are to be subsequently built up for the compound stops, the holes should only extend a short distance into the upper veneers, so as to mark their positions for future completion. By inserting three or four tightly fitting pegs in these rack-pillar holes, the marked rack-boards can at any time be replaced in their correct positions on the upper-boards. The necessity for replacing the rack-board on an upper-board which is formed of three layers of wood, and which is to be grooved in its middle layer, is obvious; for in this case two distinct series of markings have to be transferred from the rack-board—one on the upper veneer for the holes to receive the feet of the pipes, and the other on the middle layer for the holes which have to extend through it, the slider, and the table, into the wind-grooves of the frame. The veneers are not glued to the center layer until all the marking, boring, and grooving processes have been completed. When the upper veneer has been marked, it has to be removed to allow the middle layer or under veneer to be marked as required.

When all the holes for the rack-pillars have been bored as above directed, the centers of all the holes which are to receive the feet of the pipes are marked on the upper-boards, by passing a fine drill down through the pine board at the center points decided in the process of planting the pipes. The drill must be held truly vertical, or the pipes will not stand properly in the finished rack-boards. When all these centers have been drilled, the pine board is lifted so as to allow such veneers to be removed from the upper-boards as circumstances require. The pine board is then restored to its original position, and the centers of all the holes that have to be bored through the exposed middle layers and the under veneers, and any others which have to be bored in the process of grooving, etc., are marked by the drill, as before. The pine board is now removed, and is ready to be divided into the requisite number of separate rack-boards, corresponding to the upper-boards. When the veneers that have been removed are replaced and screwed down, the boring is proceeded with.

All the holes which are required for the feet of the pipes are first bored, screw-bits of assorted sizes being used, and care being taken to have the holes large enough to furnish an ample supply of wind. All the holes for the pipes which stand directly over their wind, or well within the boundaries of the sliders, are bored through the complete upper-boards, sliders, and table, into the wind-grooves of the frame. The holes for the pipes which are planted beyond the boundaries of their respective sliders, or in such positions as to require the upper-boards to be grooved, are bored through the upper veneers and only partly through the middle layers. All these holes for the reception of the feet of the metal and wood pipes retain their circular form. The upper veneers are now removed and

the remainder of the upper-boards are again firmly screwed down; and such holes as are required for the supply of wind to the grooves in the upper-boards are bored through the middle layers, under veneers, sliders, and table, into the wind-grooves of the frame below. As holes of considerable size are required for the supply of wind to the bass and some of the larger tenor pipes, and as it is desirable to secure a perfectly safe lap to cut off the wind, without requiring the sliders to have an excessive travel, it has been found necessary to adopt perforations of an oblong form in the table, sliders, and under veneers of the upper-boards. These oblong perforations are cut in a transverse direction, so as to minimize the travel of the sliders. For these perforations two comparatively small holes are bored, in each case, through the middle layers, under veneers, sliders, and table; these pairs of holes being subsequently unified by having the wood between them removed by a fine saw or chisel. To further increase the area of these perforations their ends are sometimes cut square, as shown in Fig. CLVII.

When all the boring has been completed, and the necessary grooving in the middle layers has been carefully cut, the veneers are glued on, and any special building up is executed. The upper-boards are again screwed down over the sliders and bearers, and all the holes which appear on their upper surfaces are carefully cleaned and smoothed, so far as they extend, with hot iron rods of suitable sizes. The holes for the reception of the feet of metal pipes are finished by being well countersunk with an iron tool having a turned conical end, applied sufficiently hot to char the wood. When the holes for the feet of the larger wood pipes have been carefully and cleanly bored, they do not, as a rule, require to be countersunk, while those for the feet of the smaller pipes are slightly countersunk, or just sufficiently so to make their edges perfectly circular and smooth.

The particulars above given, with respect to the formation and relative positions of the wind-chest frame, table, bearers, sliders, and upper-boards, will be clearly understood on referring to the accom-

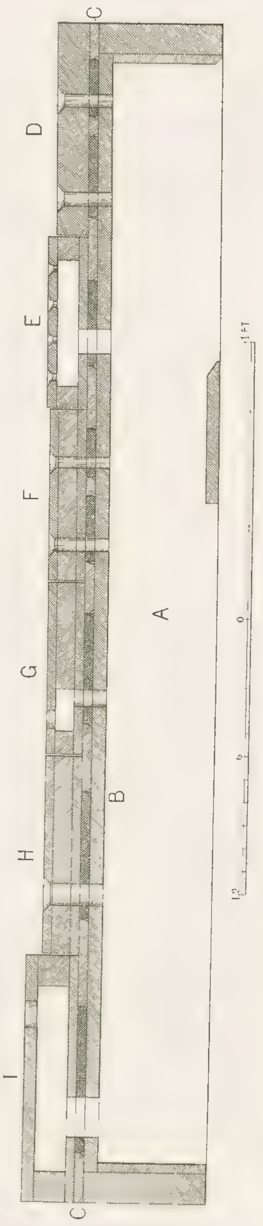


FIG. CLV.

panying Transverse Section of the upper portion of a wind-chest, Fig. CLV. This illustration shows the different modes of formation adopted for the upper-boards suitable for certain classes of stops. A is a wind-groove of the frame; B is the table; and C to C are the bearers and sliders, placed alternately, the latter being indicated by crossed lines. The first upper-board D consists of a single piece of wood, about 1½ inches thick, extending over two sliders, and bored for two stops. The holes in which the pipes stand directly correspond with those through the sliders and table, no grooving being required. This simple class of upper-board is suitable for the reception of reed stops, such as a TRUMPET or CLARINET, or any metal labial stops of medium size or small scale, the pipes of which can stand directly over their wind. The second upper-board E is for the reception of a MIXTURE of IV. ranks. Its construction has already been described and illustrated (Diagram 2, Fig. CLIV.). The third upper-board F is formed of two mahogany veneers, ⅜ inch thick, glued to a middle layer of white pine, ¾ inch thick. This is shown extending over two sliders, and is suitable for the reception of octave and super-octave metal stops, some of the larger pipes of which may require the board to be grooved. The fourth upper-board G is likewise formed of three layers of wood, and is intended to receive a wood stop, such as a STOPPED DIAPASON, LIEBLICHGEDECKT, CLARABELLA, or MELODIA. A considerable amount of grooving would be required in the bass or tenor octaves for the pipes of any of these stops, and the grooves would be formed by piercing the middle layer, as indicated. The fifth upper-board H, which is of similar construction, is intended for the reception of a unison, metal stop of large scale, such as an OPEN DIAPASON, 8 FT. The board and the slider are made sufficiently wide to render grooving unnecessary, save, perhaps, in the case of four or five of the larger bass pipes. The slider is shown divided in the center, and this cut, which is made with a fine saw, extends along it to within a few inches of each end. Sliders so divided are less liable to warp or bind. Further precautions against warping, and excessive friction due to the great weight of the metal pipes, are sometimes wisely taken by cutting an opening along the middle of a wide slider, sufficiently large to admit of an auxiliary bearer being inserted within it. The sixth upper-board I is constructed somewhat after the fashion of that for the compound stop, having a series of transverse channels or air chambers between the holes from the wind-grooves and the feet of the pipes. This upper-board is designed for the reception of a BOURDON or LIEBLICHGEDECKT of 16 ft. pitch. It has been found that stopped pipes above four feet in length are very liable to speak with an imperfect intonation when they are planted directly over their wind; and, on the other hand, are greatly improved in their speech by being placed over an air chamber, which relieves any sudden pressure. This treatment is specially desirable in pedal wind-chests. The upper-board I may be formed by perforating the middle layer, when it consists of a single thick plank; or by building it up, with side pieces and transverse partitions, on the lower veneer and subsequently gluing on the upper veneer. If preferred, the mode of construction illustrated in Diagram 3, Fig. CLIV., may be adopted.

When the upper portion of the wind-chest has been so far completed, as above described, the next proceeding is to finish the upper surface of the table and the

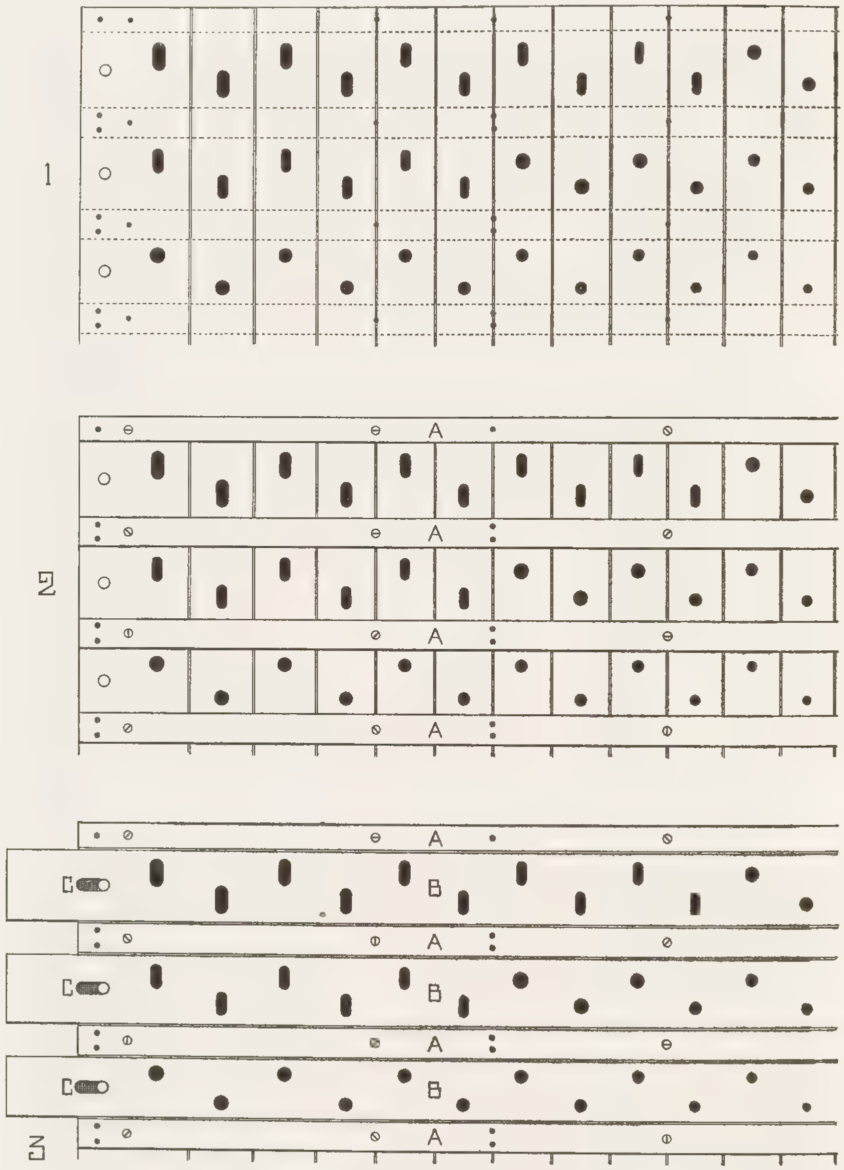


FIG. CLVI.

under surfaces of the several upper-boards. This is done by cutting V-shaped channels across them, between the pipe holes, so as to prevent any running of the wind when the sliders are not drawn. Longitudinal channels are sometimes cut in the table along the edges of the bearers; but these are not necessary when the under edges of the bearers are splayed, as previously mentioned and as shown in Fig. CLV. When the V-channeling is completed, the surfaces of the table and the upper-boards are finished by being made perfectly smooth, by means of fine glass-paper glued to a flat board, and then coated with black-lead, and brushed to a high polish. The sliders are carefully smoothed and black-leaded in a similar manner. The three diagrams given in Fig. CLVI. show portion of a wind-chest in three different stages. Diagram 1 shows the table bored and cross-channeled, as above described. The positions to be occupied by the bearers are indicated by dotted lines; and it is along these lines that the longitudinal channels will be cut when such are considered desirable. In Diagram 2 the table is shown with the several bearers A fixed in position, ready to receive the sliders and upper-boards. The small black dots on the sliders indicate the holes through which the screws pass which hold the upper-boards tightly down on the bearers. The screws pass through the bearers and table freely, and find their hold in the screw-bars of the frame below, or in brass nuts tightly screwed into the table and bars. In Diagram 3 the sliders B are shown laid on the table between the bearers A. At C are the pins, preferably made of cork, and the oblong perforations in the sliders which limit the motion of the latter, under the command of the draw-stop action. The draw-stop action is attached to the projecting ends of the sliders in any suitable manner.

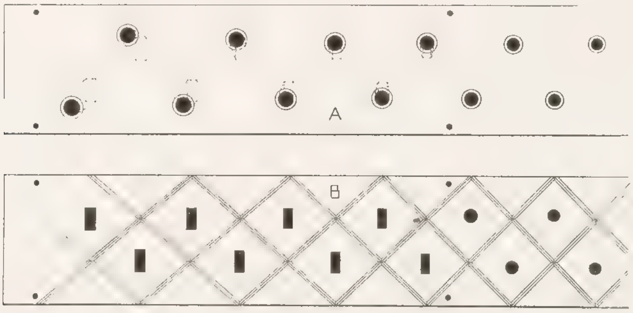


Fig. CLVII.

The accompanying illustration, Fig. CLVII., shows the upper and under surfaces of the bass portion of an upper-board, the latter surface displaying the diagonal V-channeling cut in both directions between the pipe holes. When the V-channels are cleanly cut to the depth of about ⅛ inch in both the table and upper-boards there is very little danger of any running of the wind. On the upper

surface A are shown the counter-sunk holes for the feet of the pipes. Eight of these are spread somewhat for the reception of the larger bass pipes, being grooved from the holes in the under surface B of the board, as indicated by the dotted lines. Before the upper-boards are finally screwed down, the bearers have their top surfaces covered with paper, pasted on, of sufficient thickness to relieve the sliders of all undesirable pressure from the upper-boards, and to allow of their easy movement by the draw-stop action. Upper-boards have until very recently been screwed down in a perfectly rigid manner, no allowance having been made for the unavoidable expansion and contraction of the wood. These are now provided for by a simple appliance, adopted by the Hutchings-Votey Organ Company, of Boston, Mass. This appliance, as shown in Fig. CLVIII., consists of a small and very strong, coiled steel spring, interposed between the head of each screw and the accompanying washer which rests on the upper-board. While these strong springs allow the necessary pressure to be applied, they at all times permit the wood of the upper-boards to expand or contract without affecting the correct adjustment with respect to the sliders. In a country subject to extreme dampness and drought during different seasons of the year, such an arrangement is very desirable. We strongly recommend these screw springs to be used where practicable in all movable parts of the Organ.

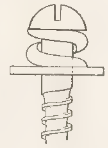


Fig. CLVIII.

Having completed all that it is necessary to say respecting the upper portion or division of the wind-chest, with the exception of the rack-boards which serve merely as supports for the feet of the pipes, we may now briefly describe the construction of the lower portion, or that correctly called the pallet-box, containing the valves or pallets which control the admission of compressed air to the pipes.

The pallet-box, in its usual and simplest form, is an air-tight box which is attached to the under face of the wind-chest frame, extending its entire length, and inclosing the portions of the wind-grooves that are covered by the pallets. The box distributes the compressed air along the entire length of the wind-chest, being supplied from the wind-trunk which is attached either to its bottom or one of its ends, as circumstances may direct. The best position for the wind-trunk entry is unquestionably in the center of the bottom board, as the wind is more equably distributed thence than when it is injected at one end of the box. The back of the box, when the latter does not extend the entire width of the wind-chest, is a thick bar of wood, called the wind-bar because the wind-trunk entry was frequently cut through it. As this bar very materially assists in giving rigidity and support to the entire wind-chest under its heavy load of metal pipe-work, it is undesirable to weaken it by cutting a large wind entry through it when it can possibly be avoided. The wind-bar is so placed as to bear on portion of the longitudinal surface provided on the under side of the frame for its reception and the reception of the leather hinges or the metal tail-pins of the pallets. The wind-bar may be faced with soft leather and screwed to the bars of the frame, or it may be permanently glued to the surface provided for it. From the outside face of the wind-bar to the back cheek of the frame all the bars and wind-grooves are covered

over with leather, oil-cloth, or other air-tight material, securely glued on, for the purpose of closing all the wind-grooves outside the pallet-box. The depth of the wind-bar, determining that of the pallet-box internally, should be from five to six

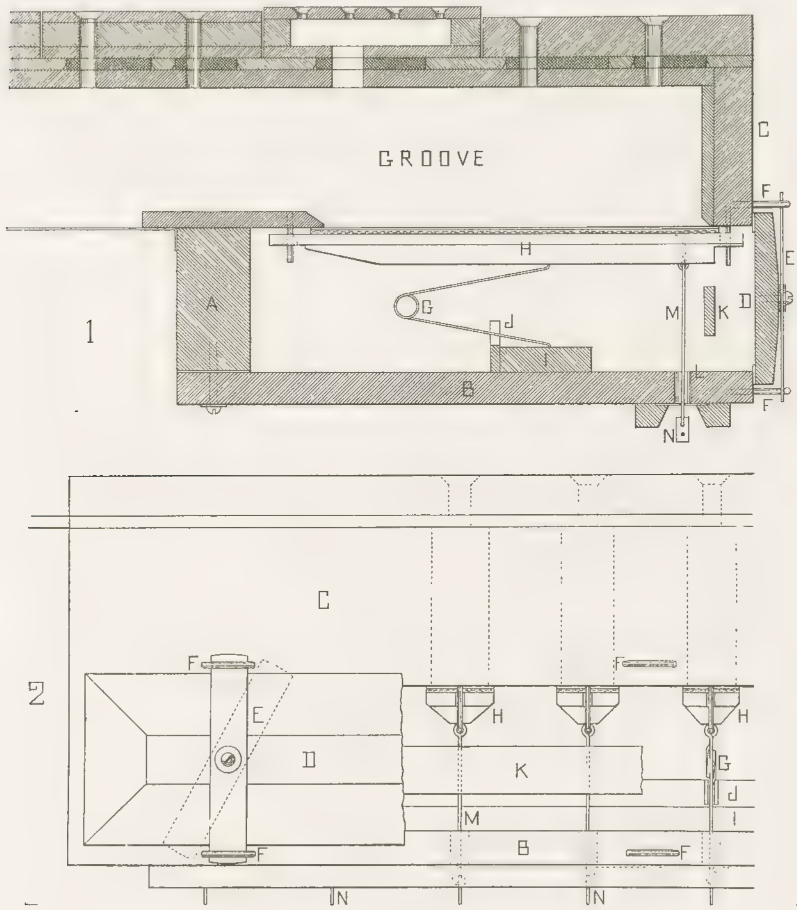


FIG. CLIX.

inches when the pallets have the simple tracker action pull-downs; but when any form of pneumatic lever is placed under the pallets, inside the box, a greater depth will, in all probability, be necessary to accommodate it. In the upper diagram (1) of the accompanying illustration, Fig. CLIX., which is a Transverse Section of

an ordinary pallet-box and the adjoining portion of the frame, etc., the wind-bar is indicated at A. The ends of the pallet-box are made the same depth as the wind-bar, and are dovetailed or otherwise securely attached to the ends of the bar, and leathered and screwed or permanently glued to the end cheeks of the frame. The wind-trunk entry may be cut in either of these ends. The bottom board of the box, shown at B, should not be less than 1 inch thick, as it has to resist the considerable pressure exerted by the numerous pallet-springs. The bottom board is tightly screwed to the wind-bar and the ends of the box, the edges of which are covered with leather to make the joint air-tight. The front edges of the bottom board B and the ends of the box are dressed flush with the face of the cheek of the frame C to receive the front board or lid of the box, shown at D. This lid may be made of straight-grained mahogany, so as not to be liable to warp; or it may be formed of a frame filled in with a panel, securely jointed and glued. Its inner surface must be edged with soft leather, and its outer surface should be sloped slightly toward each edge, as indicated. The lid is held air-tight against the edges of the pallet-box and cheek C by means of flat, steel spring bars E, pivoted in the center, and bearing against strong L-catches screwed into the bottom board and cheek, as shown at F F. The manner in which these spring bars operate and hold the lid tightly is illustrated at E in the lower diagram (2), which is a Front View showing one end of the lid, broken off, and the ends of the pallets, etc., in the open box. When the wind-chest is long, the lid should be made in two or more lengths, the ends which meet together resting against vertical pieces of wood dovetailed into the face of the cheek and the edge of the bottom board. These vertical pieces materially assist the bottom board to withstand the downward pressure of the pallet-springs. The mode of securing the front board or lid of the pallet-box differs in the works of different organ builders. The mode above described, and which is unquestionably the best, was invariably adopted by the Roosevelts. In English organs it is common to find the front boards secured by ordinary round-headed screws with washers; but if screws are to be used, those furnished with butterfly nuts are to be preferred. Arrangements of wedges have sometimes been adopted by German builders.* The old method, illustrated by Dom Bedos, was to secure both the bottom board and the lid of the pallet-box by iron straps and hooks, which were carried from the back of the wind-bar to the front cheek of the wind-chest frame. Another method only required iron hooks across the lid, which in this case was let flush into a rebate formed in the adjoining woodwork.

In the Transverse Section (1) given in Fig. CLIX., the pallet-box is shown as extending only under part of the wind-chest frame, and just sufficiently wide to properly inclose a single series of pallets; but in cases where two series of pallets are introduced throughout the compass, or in the bass octave only, it is proper to construct the pallet-box of the entire width of the frame above, furnishing it with lids on both sides. To give the desirable support, both to the frame and the bottom board of the pallet-box, that is furnished by the so-called wind-bar, it is usual

* An example of a wedge treatment is given in "Die Theorie und Praxis des Orgelbaues," Fig. 8, Pl. XVII.

to insert a thick bar along the center of the box, pierced with several circular holes to allow the compressed air to circulate freely on both sides. In a pallet-box of this class the wind-trunk entry should extend on both sides of this middle bar, so that there may be no inequality in the supply of wind from the trunk.

The pallet-box extending the entire width of the wind-chest and containing two series of pallets is required for certain special arrangements of speaking stops.

1. In the Organs constructed on the modern French ventil system, the wind-chests are divided longitudinally into two sections, and are furnished with two series of pallets which are opened simultaneously by the same key action. This "nouveau système de sommiers à doubles laies de soupapes" was introduced by M. Cavaillé in the year 1839.* In this system of construction the pallet-box, or what is equivalent to it, extends the full width of the wind-chest frame. The wind-grooves of the latter are separated into two divisions by fillings-in inserted at a certain place in their length, corresponding with the separation of the speaking stops; and under these fillings-in is fixed a partition which divides the pallet-box into two corresponding chambers. This partition is placed obliquely so as to provide as broad a surface as practicable for the reception of an oblong ventil or valve, which covers an opening cut in the partition for the passage of the compressed air from one chamber of the pallet-box to the other. The ventil is hinged to the lower face of the oblique partition, or that toward the chamber belonging to the foundation stops ("jeux de fonds"), so that it can be opened to its full extent by a pull-down wire which passes through the bottom of the pallet-box. The stops that are planted over the first section of the wind-chest are those classed by the French builders as "jeux de fonds," or foundation labial stops; and those planted over the second section are designated "jeux de combinaison," embracing the harmonic-corroborating and the reed stops. As will be seen on referring to the important French Specifications appended to this treatise, this ventil system obtains in both the manual and pedal departments. While the wind must be admitted into the first chamber before any stop can be made to speak, it can only be admitted thence to the second chamber, which commands the "jeux de combinaison," by opening the ventil of the oblique partition.† Wind-chests of this construction ("sommiers à doubles laies") are to be found in all the large Organs constructed by the late M. A. Cavaillé-Coll.

2. When stops requiring two different pressures of wind are planted on one wind-chest, a divided pallet-box, furnished with two series of pallets, is necessary. Wind of the required pressures must, in this case, be conveyed by separate wind-trunks to the different chambers of the pallet-box.

* "Nouveau système de *sommiers à doubles laies de soupapes*, l'une particulière aux jeux de fonds, l'autre aux jeux de mutation et aux jeux d'anches. Ce nouveau système de sommiers, inauguré par M. Cavaillé en 1839, permet d'alimenter sans la plus légère altération tous les jeux d'un même sommier, séparément ou ensemble, et donne lieu à de nouvelles pédales de combinaison qui créent, au profit de l'instrument, d'innombrables ressources pour l'organiste."—"Étude sur la Facture d'Orgue Moderne," p. 60.

† It is obvious when these two chambers are required to be entirely independent of each other, they can be supplied by separate wind-trunks furnished with special ventils, rendering the ventil in the partition of the pallet-box altogether unnecessary.

3. In a Chamber Organ, or other small instrument, the wind-chest may have the stops of two manual divisions planted on it. In this case, the pallet-box will extend the entire width of the frame, and the grooves of the latter will be divided by fillings-in. A perforated bearer may extend the entire length of the frame, under the fillings-in ; but should two pressures of wind be used this bearer must not be perforated. The two series of pallets will, in both cases, be entirely independent of each other.* Other arrangements may be required in special cases.

Having briefly described the general construction and the usual forms of the pallet-box, we may now consider the details of its internal appointment ; namely, the pallets and their immediate accessories, the pallet-springs, spring-rail, thumping-rail, and the pull-downs and their accessories. As a special Chapter is devoted to the description of the several forms of relief pallets which have been devised by ingenious organ builders, it is only necessary in this place to describe the old-fashioned solid pallet, which was universally used by the early English, German, and French builders. This primitive form of pallet has been retained by modern builders who have employed the pneumatic lever in connection with the tracker-action : examples are furnished by all the large Organs constructed by Cavaillé-Coll. These pallets are still used, in slider wind-chests, by certain builders who apply pneumatic levers or motors directly to them within the pallet-box. When these motors are employed it is not unusual to attach two or three pallets to some of those in the bass octave ; the pallets covering special grooves, the bars between which are perforated so as to allow the free transmission of the wind from one groove to another ; or the different grooves of each note may be arranged to serve certain pipes of different stops. This arrangement renders the use of very wide and long pallets unnecessary ; and, when the grooves are connected, it favors a simple method of relieving excessive pressure of the wind on the closed pallets. This method consists in so arranging the links between the motor and its pallets that one pallet is opened slightly in advance of the other or others, thereby neutralizing further wind-pressure.

Solid pallets are preferably made of the finest light and perfectly straight-grained white pine, which has been thoroughly weather-seasoned and naturally dried. Too much care cannot be taken to select wood for this purpose ; for it must be absolutely proof against the action of dry or damp air so far as warping is concerned. The pallets are usually sawn from cross-cut portions of a plank, jointed together, and dressed to the requisite thickness ; the edges of the board so formed are then dressed to the forms required for the front ends and the tails of the pallets, as hereinafter described. The dimensions of the pallets will be dictated by the size of the wind-chest and the nature of the stops planted thereon. As a general rule, the pallets should be made one-third the length of the wind-grooves of the frame, single pallets of this length being used in the tenor and higher octaves, and, in the case of large wind-chests, double pallets of less length being applied to

* This was the case with one of the wind-chests in our own Chamber Organ, which was divided, and had all the stops of the upper manual division and a few of the stops of the lower manual division planted on it. The remaining stops of the latter division were planted on an independent wind-chest and inclosed in a second swell-box.

the grooves of the bass octave. In very narrow wind-chests, such as are introduced in small Chamber Organs, the pallets are frequently more than half the length of the wind-grooves. No pallet should be less than 7 inches in length. Double pallets, which practically double the weight of the touch, have very rarely been used in modern Organs which have not been fitted with a pneumatic lever action. The widths of the pallets vary according to the widths of the wind-grooves they have to cover, ¼ inch being allowed for their lap on the bars of the frame—⅛ inch on each side. A greater lap is sometimes given in large work.

In the accompanying illustration, Fig. CLX., are shown the usual form of the solid pallet and the different methods of hinging and guiding it. Diagrams 1 and 2 show a Side View and Transverse Section of the solid pallet almost invariably used by English organ builders. The body of the pallet A is of light, straight-

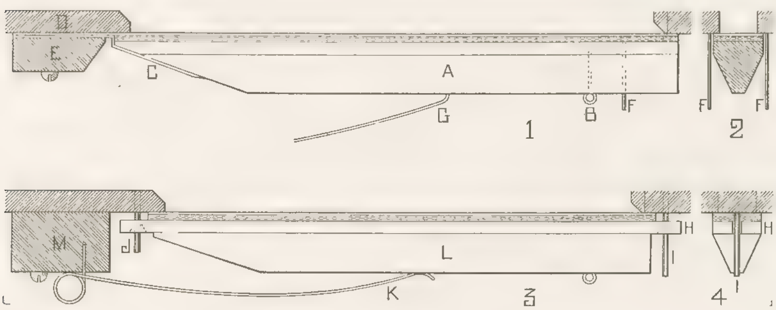


Fig. CLX.

grained white pine. When sawn from the plank, previously described, it is dressed on each side to the required width; then a center line is marked by means of a self-adjusting gauge along its lower surface, and its sides are dressed to the sloping form shown in the Section. At a point in the center line 1¼ inches from the front end of the pallet is inserted the pull-down eye B. This may be turned on the end of a short piece of brass wire, or may be made in the form of a staple, and driven tightly into the pallet. The single straight wire may pass through the pallet and be bent down and bedded on its upper surface, making the eye absolutely fast, as indicated by the dotted lines. The pallet should now receive a good coat of shellac varnish to protect it against the action of the atmosphere. When all the pallets required for the wind-chest have been brought to the stage just described they are ready to be leathered. The leather used is a stout and soft sheepskin specially prepared for the purpose and known in the trade as "pallet-leather." When leather only is used two thicknesses are glued together in the following manner: Strips are cut from the best portions of the skins, about 1½ inches wider than the length of the pallets. The smooth or dressed sides of these are well cross-scratched with the teeth of a sharp saw, so as to hold the glue. One strip is

tacked, rough side downward, on a board and the scratched side is covered with hot glue, brushed until it froths: then the second strip is laid upon the glued surface, and pressed down with a warm flat-iron so as to secure a perfect junction. When the glue is dry, the leather is removed from the board and well pulled in different directions, for the purpose of breaking up the hard layer of glue and rendering the leather more soft and pliable. The double leather is again tacked to a flat board and stretched tightly. The upper surface of each pallet, previously scratched with a toothing-plane, is now covered with very hot glue, and immediately pressed down, with a slight rubbing motion, on the leather, the front end of the pallet being laid close to one edge of the strip, so as to leave the hinge piece at its tail. The pallets are laid side by side, with about ⅛ inch of leather exposed between them, and allowed to dry under a slight pressure. When the glue is perfectly hard, the leather is carefully cut around the sides and front ends of the pallets, and the hinge pieces extending from their tails are trimmed to the requisite length. To prevent any possibility of the tails of the pallets becoming detached from the leather, a piece of skiver is sometimes glued over the hinge pieces and along the sloping tails of the pallets, as indicated at C in Diagram 1. When these pieces of skiver are trimmed with a sharp knife to the pallets and hinge pieces, the pallets are ready to be fixed in their places on the frame of the wind-chest. A sheet of sharp-cutting glass-paper is glued to a flat board, and its surface is covered with powdered chalk. On this the leather face of each pallet is rubbed until all inequalities are removed, and the chalk is driven into the spongy surface of the leather. The face of the hinge piece is now brushed over with hot glue, the pallet laid in its place, and the hinge piece pressed tightly on the bars and fillings-in, as indicated at D. A heavy weight is laid on the hinge piece, and is moved on as each succeeding pallet is fixed. When the entire series of pallets are glued down, all the hinge pieces are further secured by means of a strip of wood, laid over them, and screwed or nailed to the bars at intervals. The section of this strip is shown at E. The front end of each pallet is held in correct position over its groove by means of two hard brass or phosphor-bronze wire guides F F driven into the bars of the frame close to the edges of the pallet, as indicated. At a point in the center line formed by the gauge, and at the distance of five-twelfths of the length of the pallet from its front end, is drilled a small indentation for the reception of the upper arm of the pallet-spring, shown at G. In the Diagrams 1 and 2 the pallet is shown covered with a layer of fine felt, about ⅛ inch thick, faced with stout pallet-leather. The felt is not carried beyond the tail of the pallet, the leather facing and the skiver covering forming the hinge piece.

In the Diagrams 3 and 4, Fig. CLX., are given Side and End Views of a solid pallet of a much better form than that above described. The front end of the pallet is checked so as to provide a projecting piece H, which is forked for the reception of a phosphor-bronze guide-pin I. The inner edges of the fork are carefully smoothed and black-leaded so as to glide on the pin with practically no friction. The tail of the pallet is hinged on a phosphor-bronze tail-pin J, about ⅛ inch in diameter, much in the same manner as a manual key is hinged on its mid-pin. This simple arrangement allows the pallet to be readily removed from

its seat at any time to be cleaned, re-surfaced, or repaired. It is covered with fine felt and soft pallet-leather, leaving the front fork and the hole for the tail-pin free, as indicated. In all other respects this pallet is similar to the one previously described. The process of covering the pallet is as follows: A strip of thick and very soft pallet-leather, in width about the length of the pallet, is tacked, rough face downward, on a flat board, and its dressed surface well cross-scratched with a sharp saw, and along with it is provided a strip of colored felt of similar size and about 1/8 inch thick. The scratched surface of the leather is now covered with very hot glue and rapidly worked with the brush until a froth is produced. On this the felt is immediately laid, and pressed down with a wooden roller until a perfect junction is secured. A board and heavy weights are now laid on the felt, and the glue is allowed to dry. When the glue is dry, the strip of felt and leather is trimmed to the exact width required for the pallet covering. The face of each pallet, well scratched with a toothing-plane, is covered with hot glue between boundary lines, previously marked across each end, and immediately laid in correct position across the strip of felt, and firmly pressed down to insure a perfect attachment to the surface of the same. The pallets are laid side by side with about 1/8 inch of clear space between them. When a few pallets have been glued down, a narrow board is laid across them and a heavy weight placed thereon. This weighted board is moved along as more and more pallets are added until the strip of felt is covered. When the glue is perfectly dry, the pallets are separated by carefully cutting through the felt and leather along their sides. In a pallet of this class the spring should bear on a point slightly in advance of the center of its length, as indicated in Diagram 3; but some builders prefer to place the point somewhat nearer the tail, with the view of preventing any tendency in the tail to leave its seat when the pallet is rapidly moved in *staccato* playing. The usual form of the pallet-spring is shown at E and F, in Fig. CLXII., and, in its proper relation to the pallet, in the Section given in Fig. CLIX. The form of pallet-spring shown at K, in Fig. CLX., is one sometimes used by American organ builders for pallets actuated by pneumatic motors located within the pallet-box. This spring has only one effective arm, the curved end of which rests in a depression on the under side of the pallet; its other end is looped and secured in a saw cut in a bearer adjoining the tail of the pallet, as indicated at M.

The pallet-springs are made of hard brass or steel wire, 18, B. W. G., preferably of the latter. Before the springs are formed the wire, which is supplied in coils, is straightened by being drawn past an arrangement of steel pins driven into a piece of hardwood. The disposition of the pins and the path of the wire as it is drawn between them are shown in Fig. CLXI., which is a Top View of the contrivance. A is the hardwood board, and 1, 2, 3, 4, 5, 6 are the steel straightening pins. The wire B coming from the drum on which the coil is placed, in the direction indicated by the arrow, passes successively between the six steel pins and issues at C perfectly straight and ready to be formed into springs. The simplest method of forming the pallet-springs is by means of the appliance shown in Fig. CLXII. This consists of a piece of hardwood A in which a round peg of brass or iron, about 1/2 inch in diameter, is fixed at B, and two steel pins are driven in at

C and D, forming an equilateral triangle the sides of which are 5 inches long. To form a spring, a piece of wire is taken, slightly longer than is required, and about $\frac{3}{16}$ inch of one end is bent to a right angle. This is placed against the pin C, and, firmly held, the wire is tightly coiled twice around the peg A, and then drawn straight and bent to a right angle against the pin D, as indicated. The spring is removed and the waste length is cut off so as to have the bent points of both arms exactly alike. The appliance just illustrated and described was evidently used by

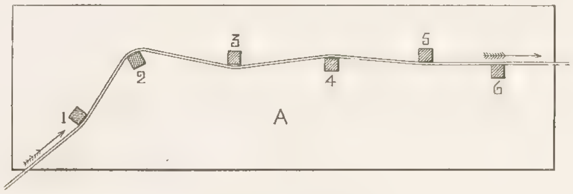


Fig. CLXI.

the old builders, for it is given by Dom Bedos in "L'Art du Facteur d'Orgues" (Plate LVI.). When many springs are required, a simple machine having a revolving spindle, furnished with an arm to carry the spring wire, and a handle to turn it by, is used. Such a machine is illustrated in "Die Theorie und Praxis des Orgelbaues" (Plate XIX). By its use springs perfectly uniform in shape and practically equal in strength are quickly produced.

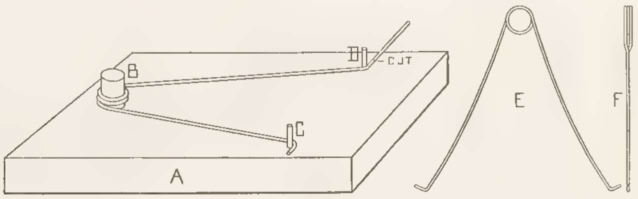


Fig. CLXII.

The pallet-spring is finished by having its arms set by means of pliers so as to bring them into one plane, and then having a slight outward curve given to them by bending them between folds of leather held tightly between the fingers. The spring is brought to the desired degree of strength by holding the coil, exactly where the arms leave it, firmly with round pliers, and bending the arms inward or outward until the points are the necessary distance apart. A Front View of a finished spring is given at E, and a Side View at F showing the set of the arms. When the strength required has been arrived at by the adjustment of a single spring, it is desirable that all the other springs of the series of pallets be brought to correspond with it. This can be readily accomplished with the aid of

the simple contrivance shown in Fig. CLXIII. The ends of the spring are inserted in indentations in the base A and the lever B; and the weight C is moved until the lever is depressed to any mark on the vertical scale D. When this has been recorded, the originally adjusted spring is removed, and the other springs are weighed and altered until the lever B drops to the proper mark on the scale. Springs so adjusted impart an almost perfect regularity to the pallet action throughout the wind-chest. It may be said, however, that organ builders are usually satisfied with a much less accurate system of adjustment, which rarely

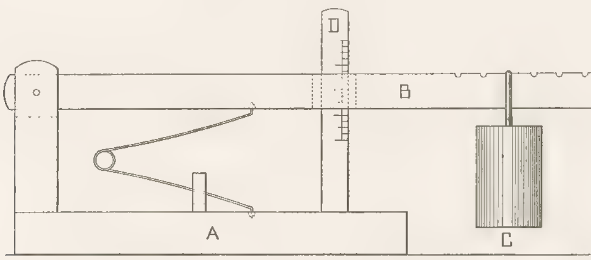


Fig. CLXIII.

extends beyond seeing that the ends of the springs are all the same distance apart. The "rule of thumb" obtains to an undesirable extent in modern organ-building; and the neglect of the many refinements of construction has brought the tracker and pallet actions into undeserved disrepute.

The position of the spring with respect to the pallet is shown at G in the Transverse Section of a pallet-box given in Diagram 1, Fig. CLIX. The bent end of the upper arm of the spring rests in the indentation made in the pallet H, as already described; while the bent end of its lower arm is inserted in a similar indentation made in the spring-rail I. This rail, which extends the entire length of the pallet-box, is screwed to the bottom board B, and has attached to its rear edge a thin piece of wood, formed into a comb J by vertical saw-cuts, in which the lower arms of the springs are retained in position, as indicated. The saw-cuts are chamfered on their front edges in the form of a V so as to allow the springs to move without unnecessary friction. One other strip of wood completes the internal woodwork of the pallet-box; this is the thumping-rail K, consisting of a thin piece of white pine sprung into mortises cut in the ends of the pallet-box. The thumping-rail is placed so as to prevent the pallets being jerked by any quick movement off their guide-pins; but sufficiently low down so as not to be struck by the pallets in ordinary playing. The thumping-rail may be supported at intervals along its length by small brass L-plates, or by screws passed through the vertical pieces of wood which are dovetailed into the face of the cheek C and the bottom board B, as previously mentioned.

We have now to consider the formation and the adjustment of the pull-down wires and their adjuncts, which practically complete the wind-chest. When the

pallets are secured by their leather hinge pieces, or are placed in position on their tail- and guide-pins, the exact distances of their pull-down eyes are marked on a wooden rod; and the distance from them to the front of the wind-chest cheek is accurately measured. A line is now drawn on the bottom board of the box, at the latter distance from its front edge (the board being at this stage detached from the wind-bar and the ends of the box), and on this line the positions of the pull-down eyes are transferred from the rod. At these points, along the line, holes about ¼ inch diameter are bored through the board, and are subsequently charred with a burning-iron to remove any free particles left by the boring tool. These holes are for the passage of the pull-down wires. One of these holes is indicated at L in Fig. CLIX. To hold the pull-downs in correct position, and make their passage air-tight, a strip of sheet brass, a little less than $\frac{1}{16}$ inch thick and about 1½ inches wide, is taken, carefully flattened, and a center line scratched along it; and on this line are cross-scratched the distances of the pull-down eyes, transferred from the wooden rod; and then at each point so marked a hole is drilled of sufficient size to allow the pull-down wire to pass easily through it. The burrs caused by the drill are removed with a small rose or countersink bit, and the holes are cleared by passing a steel burnishing wire through them. When the strip of brass is completed it is fixed in correct position on the under side of the bottom board, so that the pull-downs will be perfectly vertical when the pallets are drawn down half their proper fall. The brass strip is sometimes bedded on a strip of leather, glued to the bottom board, and perforated to correspond with the holes bored in the same; at other times it is simply bedded in a coating of thick glue. The brass is first held in position by small tacks along its edges, and finally securely fixed by two strips of wood, glued and screwed to the bottom board. A section of this por-

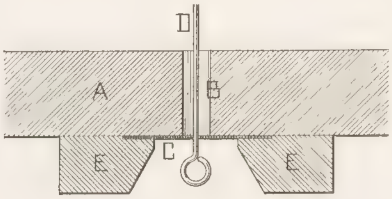


FIG. CLXIV.

tion of the pallet-box is given in Fig. CLXIV. A is the bottom board; B is one of the ¼ inch holes bored through it; C is the brass strip drilled for the passage of the pull-down wire D; and E E are the two strips of wood, which hold the brass strip, and serve to protect the lower eyes of the pull-down wires. The pull-down wires are made of plated iron, hard brass, or phosphor-bronze, 18, B. W. G.; but the last material is to be preferred. The upper ends of the wires are tightly hooked into the eyes of the pallets; and their lower ends are passed through the perforations in the brass plate and turned into circular eyes, as indicated at M, in Fig. CLIX. The vertical trackers or pull-downs of the key action are connected

with the eyes by means of a link of stiff tanned leather, shown at N in the same illustration.

The wind-chest is completed by the addition of the rack-boards, which are supported at the distance of about 4½ inches above the upper-boards by a series of turned wooden rack pillars. These pillars fit tightly into the holes bored for their reception in the upper-boards; and, at top, pass tightly through corresponding holes bored in the rack-boards. The end of an upper-board with its rack-board is shown in Diagram 1, Fig. CLXV. The rack-board A is supported by the pillars B B. The pipe C passes through a hole cut in the rack-board, and rests in its wind hole in the upper-board D. The rack pillars have sometimes

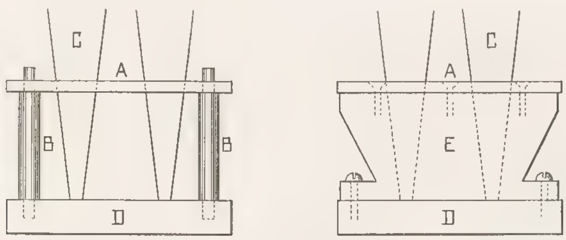


FIG. CLXV.

screws and wooden nuts on their upper ends, by means of which the rack-boards are firmly held. This method is to be recommended, as it allows the rack-boards to be easily removed at any time without disturbing the pillars on the upper-boards. Instead of pillars, solid end supports are sometimes used, as shown at E in Diagram 2. These are about ⅞ inch thick, and are shaped and screwed to the upper-boards in the manner indicated. The rack-boards are, in turn, screwed to the upper edges of the supports.

The rack-boards, which have been marked with the centers of the pipes in the manner previously described, are now bored for the reception of the feet of the metal and wood pipes. This is done by means of ordinary center bits in the case of the smaller pipe-feet, and by an expanding bit in the case of the larger pipe-feet. The holes are bored a trifle smaller than is necessary and then enlarged, by a half-round rasp or a coarse rat-tail file, until a satisfactory fit is obtained. The holes for the larger metal pipes should be lined with thick pallet-leather. All pipe-feet should rest easily in the rack-board holes, so that there can be no tendency to lift the pipes from the wind-holes in the upper-boards. A slight allowance should be made for the possible contraction of the rack-boards across their grain. This precaution will prevent the feet of the pipes being pinched, or lifted from their holes.

There is probably no detail in organ construction to which no exception can be taken from some point of view, and the slider and pallet wind-chest, time-honored as it is, has certainly come in for its full share of disapproval in certain

quarters. Some of the objections which have been advanced are worthy of careful consideration, while others do not seem to call for any special attention. At the present time the slider and pallet wind-chest is practically condemned by what may be called the advanced school of organ builders; and in many instances it has fallen under just condemnation, not so much on account of its system of construction, as through the unskilful and incorrect manner in which it was, in such instances, constructed. It must not be forgotten that there are slider wind-chests and slider wind-chests which are alike in name only. We have had experience with at least one example which we would under no circumstances have exchanged for any other form of wind-chest which has been invented, but this example happened to be properly proportioned and constructed in all its parts. There is the cramped and starved wind-chest of the cheap, competitive builder, in which every inch in its length, width, and depth has been grudgingly given; in which the materials are of the cheapest and scantiest description; in which the wind-grooves are both too shallow and too narrrow for the work they have to do; and in which the pallets are too short to admit the necessary amount of wind. On the other hand, there is the nobly proportioned wind-chest of the old German masters, sufficient in length and width for every pipe planted thereon to stand over its wind and find ample room to speak; in which the wind-grooves are deep and wide, and for the lower notes double; and in which the pallets are correspondingly large and very commonly duplicated. It is not just to condemn the latter kind of wind-chest because of the shortcomings of the inartistic and unscrupulous mechanic who to-day turns out a piece of work which is a wind-chest only in name.

It is a remarkable fact, and one that should be recognized, that at the present moment the grandest and most satisfactory Organs in Europe are fitted with slider and pallet wind-chests. In proof of this it is only necessary to mention such instruments as those in St. George's Hall, at Liverpool, and in the Church of Saint-Sulpice, at Paris. There are hundreds of Organs in Europe which as musical instruments, in the true sense of the word, have never been surpassed by the works of the builders who have abandoned the time-honored slider and pallet wind-chest. We are free to admit, however, that modern requirements and methods call for a different class of mechanism; and there is no reason why we should, in recognizing certain good features in the old form of wind-chest, shut our eyes to the great utility of the ventil wind-chests controlled by tubular-pneumatic and electro-pneumatic actions. The matter may be summed up thus: Each form of wind-chest has its own special value; and modern organ builders would do well to bear this fact in mind, and exercise unbiased judgment instead of riding some hobby to the exclusion of much that is desirable in other treatments. Of course each ingenious organ builder thinks he has the finest thing in wind-chests ever made; but until he succeeds in producing better Organs than those which have been constructed on other methods, his opinion of his own method is valueless. As we have said elsewhere, there is at the present time far too much stress laid on mechanical excellence and its attendant complexity, and far too little attention paid to scientific and artistic tonal appointment—that which makes the Organ the "King of Instruments."

The chief objections to the slider and pallet wind-chest are: First, that, from the nature of its construction, it tends to rob the pipe-work of its proper amount of wind when all or the greater number of the stops planted on it are drawn. Secondly, because the pallets, having both the pressure of their springs and the compressed air upon them, create a very heavy touch. The former objection, while it is to a certain extent valid, has been practically overcome by a careful calculation of demand and supply; and in such immense Organs as have just been named there are no indications of robbing of the wind or of deterioration of the tone in the full combinations. Such masters in their art as Willis, Cavaillé-Coll, and Schulze, never made mistakes in so vital a matter as wind supply. It has been left to the cheap and inartistic builders to bring the slider and pallet wind-chest into disrepute, just as they are bringing other important details of organ construction down to a low grade.

This Chapter would certainly be incomplete without some allusion to the attempts of certain early German builders to get rid of the more or less troublesome sliders, while they retained the grooved and palleted wind-chest. One example will be sufficient for our purpose; namely, the wind-chest of the Rückpositiv in the Organ in the Cathedral of Hildesheim, constructed by Henning Henke, in 1612. The accompanying illustration, Fig. CLXVI., will explain the general principle of

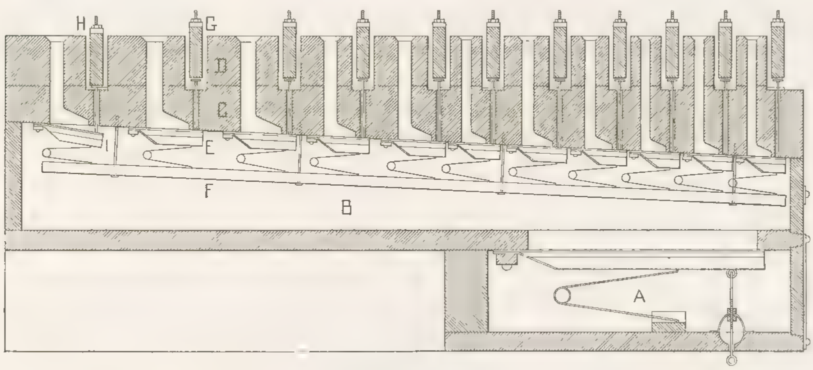


Fig. CLXVI.

construction. It is a Transverse Section of the chest, showing the interior of one of its wind-grooves and pallet-box.* It will be observed that the chest is constructed for eleven stops, the pipes of which are apparently planted in single ranks. The pallet-box A presents nothing uncommon according to the old method of construction; but the wind-groove B presents a very remarkable equipment. All the holes leading from the groove, through the intermediate and upper-boards C

*This illustration is little more than a sketch, having been rendered from a very rough German drawing in our possession.

and D, to the feet of the pipes, are covered with small pallets E, held against the holes by springs and the spring-rail F. By this arrangement there are eleven pallets in every groove of the frame, or one to every pipe planted on the chest. In the spaces left between the longitudinal upper-boards D are longitudinal stop-beams G, which extend the entire length of the chest, and are raised and lowered by rods and squares connected with the draw-stop action. The rods pass down through holes bored in the thick, transverse bars of the frame, placed at proper intervals for the purpose. Vertical holes are bored through the intermediate boards C, which extend transversely across the chest, and meet over the bars of the frame which are leathered to receive them. The vertical holes receive push-down wires, furnished with flat heads, and blunt ends which rest upon the free ends of the small pallets, as indicated. When the stops are not drawn the valves remain closed, and the push-down wires have their flat heads close to the under edges of the stop-beams G. But when a stop is drawn, its corresponding beam is depressed, and the valves under it in every wind-groove are pushed open by the wires, in the manner indicated at H I. Complicated as such a stop movement was, it was frequently resorted to by the builders of the seventeenth century. We have records of several old Organs in which the same principle of construction was adopted, but these need not be dwelt upon here.

With respect to the pallets used in the ordinary slider wind-chests, much has been done by ingenious builders to remove the objections to their use. Lightness and uniformity of touch have been practically secured by the introduction, in large Organs, of the pneumatic lever, and, in instruments of lesser size, by the use of relief pallets. It is not necessary to enter on these latter subjects here, for they are treated with all the necessary fulness in the Chapters specially devoted to them. That on the Relief Pallet immediately and properly follows the present Chapter.

CHAPTER XXV.

THE RELIEF PALLET.

IN this era of tubular-pneumatic and electro-pneumatic actions there is a decided tendency to depreciate earlier mechanical expedients. We do not, however, sympathize with this uncalled-for neglect of the ingenious inventions of the earlier masters of the art of organ-building: and in the present treatise we do not intend to altogether overlook those which are worthy of recognition. While we readily admit that great advances have been made of late years in the mechanical departments of large Organs by the introduction of tubular-pneumatic and electro-pneumatic actions, we are strongly of opinion that the retention of what is called, by way of disparagement, the "old-fashioned tracker-action," is to be recommended in cases where it can be legitimately and effectively used. Such being our view of the matter, we unhesitatingly devote a short Chapter to the consideration of those ingenious devices which have been introduced for the purpose of overcoming the most objectionable elements in such tracker actions; namely, the resistance and strain caused by the pressure of the condensed air upon the closed pallets of the wind-chest.

The devices alluded to are known as Relief Pallets—more or less simple mechanical appliances introduced for the purpose of relieving the manual and pedal keys from excessive strain, and, accordingly, with the desirable end of lightening the touch. Relief pallets are specially useful in the lower octaves, where large or twin pallets are necessary for the proper supply of wind to the bass and tenor pipes. In Organs where no pneumatic action is introduced, relief pallets are important adjuncts to the mechanism of the manual claviers. When a pallet reaches the dimensions of twelve or fifteen inches in length by an inch and a half or two inches in width, it is obvious that under the combined pressure of the pallet-spring and the compressed air in the pallet-box considerable force will be required to

draw it away from its seat. Once open, however, even to the slightest degree, all the pressure from the wind is neutralized, and the strain is reduced to that caused by the action of the pallet-spring alone; the wind, being on all sides of the pallet ceases to exert any local pressure upon it.

With the view of reducing to a minimum the pressure of the wind upon the pallets at the moment of opening, or to render the opening of the pallets easier by an arrangement of levers, organ builders have invented pallets of compound forms, or fitted them with certain adjuncts, more or less efficient in their action. To give a clear description of all the relief pallets of any value which have been used by different builders is the office of the present Chapter.

The earlier forms of relief pallets consist of two parts so arranged that one, which is much smaller than the other, or less under local pressure of the wind, shall open, to a very slight extent, before the main portion is influenced by the pull-down. The opening or lowering of the lesser part allows the compressed air to rush into the wind-chest groove in sufficient quantity to instantaneously relieve the rest of the pallet from practically all pressure save that exerted by the spring. The depression of the key and the corresponding opening of the pallet are so quick and practically simultaneous that no appreciable unsteadiness can be observed in the intonation of the pipes. It is easy, however, by very carefully and slowly depressing a manual key to find out when an Organ is fitted with compound relief pallets: the pipes will commence with a weak or uncertain tone, developing to their full intonation on a further depression of the key.

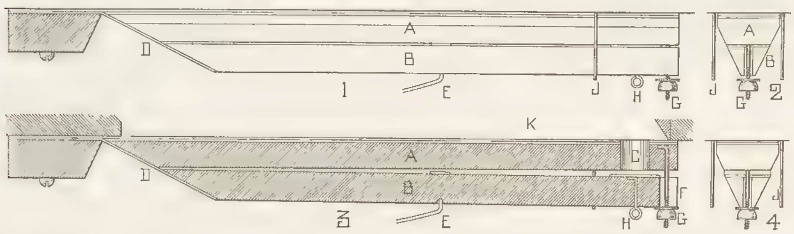


Fig. CLXVII.

In Fig. CLXVII. are given Side and End Views and Longitudinal Section of one of the simplest and most easily constructed compound pallets. It consists of two pieces of light, straight-grained bay-wood or white pine of the forms shown; the upper one of which, A, is covered on its upper face with felt and leather or two-ply pallet leather, and hinged in any approved fashion so as to bed accurately against the wind-chest bars, etc. This piece has the hole C bored through it near its free end, and the leathering cut away to correspond. The lower piece B is less in length and width but rather deeper than the upper, and is hinged to it at D. Upon the upper face of the piece B are glued two pieces of soft, one-ply pallet leather, one near the free end, and extending inward just sufficiently to cover the hole C; and another very narrow piece directly over the bearing of the pallet-

spring E. These pieces of leather, along with the lap of the hinge, keep the two portions of the pallet slightly apart from each other, allowing the wind to pass between them for about four-fifths of the length of the lower portion. To keep the pieces of the pallet opposite each other at their free ends, a small slot is cut through the lower one at F, sufficient to allow the tapped-wire, fixed to the upper piece, to pass freely downward and receive the adjustable leather button and cloth washer at G. The eye for the pull-down is fixed in the lower portion at H ; the pallet-spring having its point of bearing near the center of this portion at E. The guide wires J are fixed as for the ordinary pallet.

The action of this pallet is both certain and simple. In the Side View, 1, it is shown at rest, the pallet-spring pressing all together and closing all access to the groove. At 2 is an End View of the pallet in the same closed condition. The Longitudinal Section, 3, shows the pallet in the earlier stage of its opening. The first touch of the finger on the key has pulled down the lower portion B, which, on account of its only presenting about one-fifth of its surface to the upward pressure of the wind, is very easily unseated and moved the required distance—about one sixteenth of an inch—or until it reaches the cloth and button G, where it is arrested so far as its independent movement is concerned. The instant this operation takes place the wind finds its way between the ends of the upper and lower portions and rushes through the hole C, into the groove K, removing almost entirely the pressure from the larger portion A, which accordingly follows the lower portion in its downward motion without much additional strain on the key action. The End View, 4, shows the pallet in the earlier stage of its opening. When this pallet is carefully made, and the spring adjusted so as to be no stronger than is necessary to recover the action and to bed the pallet securely, the touch is very satisfactory.

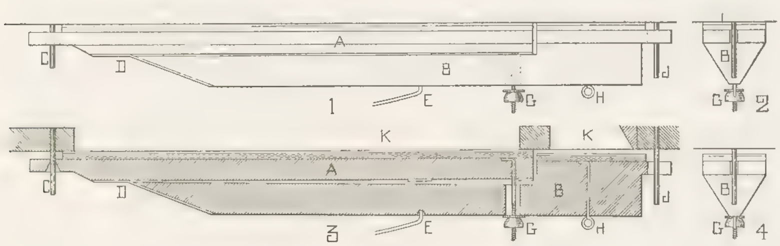


Fig. CLXVIII.

It may be mentioned here, that to secure the full benefit of relief pallets and to prevent ciphering, the action between the keys and the pull-downs of the pallets should be perfectly balanced and free from all unnecessary friction.

In Fig. CLXVIII. are given Side and Ends Views and Longitudinal Section of what is known as "Hill's relief pallet," it having been invented by Messrs. Hill & Son, of London. Though this appliance is also composed of two main pieces, it is somewhat different in its mode of action from that previously described.

Its construction is extremely simple, and may be easily understood from the drawings given. The portion A, about four fifths the entire length of the bedding surface of the pallet, is hinged on a pin at C, and beds along its edges on the wind-chest bars, and at its free end on a small bridge-piece which crosses the groove K, as shown in the Longitudinal Section, 3. The portion B, which is about the same length as A, is hinged with leather to the portion A, at D, and extends forward and upward in such a manner as to form a small pallet or valve to the shorter opening of the groove K, between the bridge and the front cheek of the wind-chest. A clear wind space is left between the portions A and B from the hinge D to the bridge, except where two narrow strips of leather are glued on the under side of the portion A, one immediately over the bearing of the pallet-spring E, and the other at the free end, close to the adjusting tapped-wire G. The two portions are held in proper relative positions by the tapped-wire and leather button G, which passes through a slot in the lower portion B. A small round-headed screw and cloth may be used if preferred. The eye for the pull-down H is fixed to the lesser pallet; and the spring bears upon the latter at E. An End View of the closed pallet is given in drawing 2, while drawing 4 shows the pallet in the earlier stage of opening. The Longitudinal Section, 3, Fig. CLXVIII., also shows the pallet in the process of opening.

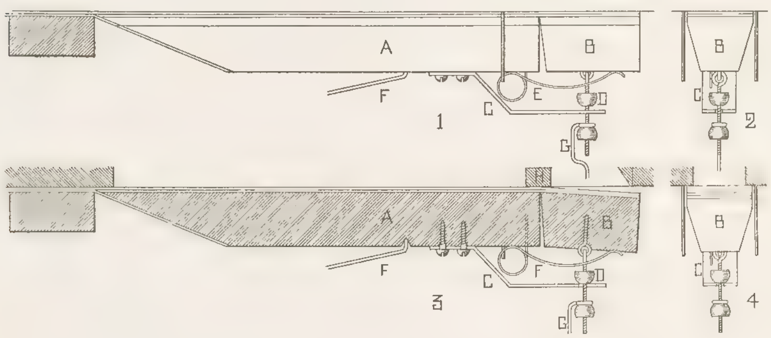


Fig. CLXIX.

The action of this compound pallet is as follows: On touching the manual key, the lesser pallet B is pulled down until checked by the leather button at G for an instant of time; at this stage, the compressed air in the pallet-box rushes into the wind-chest groove K, establishes an equilibrium, and immediately releases the larger pallet A, which falls away from its seat and follows the lower portion in its downward motion without any additional strain on the key action. The pallet is kept in position by the front pin J, on which the nose is forked, and moves freely. This pallet is not quite so easily made and fitted to its seat as the one previously described; and, on account of the larger surface the relieving valve presents to the compressed air, it is not so light in its operation.

A relief pallet invented by Mr. Holt, of Bradford, Yorkshire, and known as "Holt's pallet," is fully illustrated in Fig. CLXIX. It consists of a straight pallet of light bay-wood or pine, divided transversely into two unequal portions A and B, and hinged together by the facing of two-ply pallet-leather; one end of the shorter portion B being sloped somewhat, so as to allow this shorter portion to have a slight motion on the hinge. Both are glued to the double facing leather with their upper edges in contact, as shown in the Side View, 1. Attached to the under side of A is an iron or brass arm C, forked at its end to allow the buttoned wire D to pass through it freely. The small spring E is attached to the end of A, and exerts sufficient pressure on B to recover the action as the pallet finally closes. The main pallet-spring bears on the longer portion at F. The short pull-down wire D, linked to the eye fixed in the shorter portion B, is tapped and has a leather button for regulating the opening and closing of the portion B. A second button below secures the bent eye of the wire G, which passes down through the bottom of the pallet-box in the usual manner. Drawings 1 and 2 are Side and End Views of the complete pallet, closed, and at rest. The Longitudinal Section, 3, and End View, 4, show the pallet in the first stage of its opening.

The action of the pallet is very simple. As the finger touches the key, the pull-down first draws the shorter portion of the pallet from its bed, about one sixteenth of an inch, or until the upper button rests against the metal arm C. The wind finding its way into the groove H, through the opening so made, instantly reduces the upward pressure of the condensed air on the longer portion of the pallet A, allowing the whole to be easily drawn down, the only resistance being that caused by the main pallet-spring. In closing, the longer portion A is first bedded by the main spring; after which the smaller spring F comes into operation and returns the shorter portion of the pallet B to its bed, completely closing the groove.

The three relief pallets above described are formed on one principle—that of employing two valves of different dimensions, the smaller opening before, and releasing, the larger—but the one which we now have to notice is widely different both in construction and operation.

This relief pallet, illustrated in Fig. CLXX., was invented by Mr. Henry Willis, the celebrated organ builder, and patented by him in the year 1861. In giving a description of this ingenious appliance, we cannot do better than quote certain passages of the Patent Specification: "This invention relates, first, to the employment of certain means of overcoming the resistance caused by the pressure of the air upon the valves of the Organ, and for reducing the noise occasioned by their closing, the object being at the same time to retain the simplicity of action of the ordinary valve. Attempts have already been made to secure these results, but only partial success has attended them; thus, in the arrangement known as 'Barker's,' a double pallet, one overlaying an opening in the other is employed. Another arrangement, in which also the pallet is divided into two parts, is known as 'Holt's.'" This latter pallet is illustrated in Fig. CLXIX., while the original Barker relief pallet is shown in the Side and End Views and Longitudinal and Transverse Sections in Fig. CLXXI. It does not require description. Mr. Willis

continues: "In both these [pallets] the inconveniences complained of are but partially remedied. In order, however, fully to accomplish the desired end, I adopt the arrangement shown in Longitudinal Section, 3, and in Cross Section, 4" [in Fig. CLXX.]. The pallet A is externally of the form commonly used for the bass

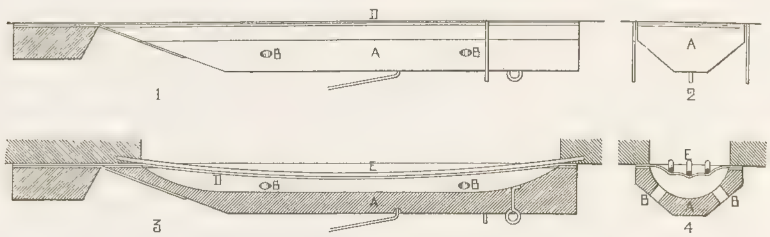


Fig. CLXX.

grooves of the wind-chest, consisting of a single piece of light, straight-grained bay-wood. This is "hollowed out," says Mr. Willis, "on that surface which is to receive the leather packing to such an extent as to leave only that portion of its face which laps the valve seat. The valve is then covered with leather [D] as usual. Through the back of the valve at any convenient part holes [B] are bored to admit the compressed air to the back of the leather; and to prevent this packing from being blown into the chamber or groove in the form of a sack (by reason of the air from the wind-chest [pallet-box] pressing on its back surface), a grating [E] is placed over the opening which the valve covers. It will greatly enhance the effect if the bars of the grating be cambered so as to press the packing into the excavated portion of the valve, [as shown in the Longitudinal and Transverse Sections in Fig. CLXX.]. The mode of operating the valve will be the same as

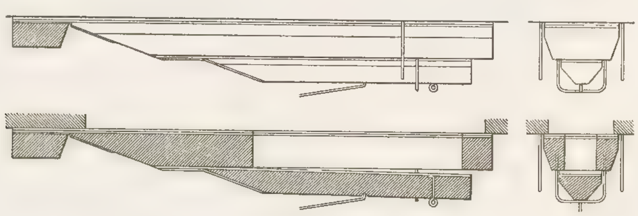


Fig. CLXXI.

usual; its action will be as follows: When the performer touches the key that commands the valve, the rigid portion or frame of the valve will first rise from its seat (being scarcely affected by the pressure of the air), and carry with it the outer parts or edges of the packing leather. This will allow the compressed air to pass the lips of the valve in sufficient quantity to relieve the pressure remaining on the still stationary portion of the valve covering. As the valve is opened the packing

leather will become inflated and form a convex surface.* On the closing, therefore, of the valve, the flexible sack will first meet the grating, and strike it silently like an air cushion. The air will then escape out at the holes in the back of the valve, and the packing will then lie upon the grating."

The disposition described by Mr. Willis is shown in the Sections, 3 and 4, in Fig. CLXX. In these drawings the grating is indicated as being of wire, as in the Patent Specification; but the use of any ordinary wire is objectionable. All pallet leather contains a certain dressing, which in the course of time acts on the metal, and produces a corrosive substance which, in turn, injures the packing and impairs the value of the pallet. Instead of wire, therefore, it is advisable to use thin splints of hardwood, fixed on edge in the wind-chest grooves, rounded, and cambered on their lower edges where they come in contact with the pallet-leather, similar in these respects to the wire grating. This description of pallet, when properly constructed, is highly suitable for Pedal Organ wind-chests and the lower bass notes of manual wind-chests. Its inventor sometimes introduced it in both bass and tenor octaves.

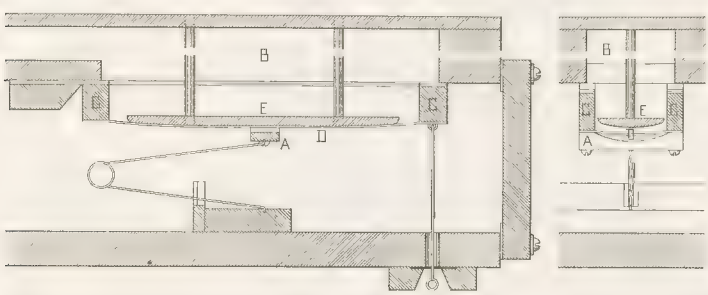


Fig. CLXXII.

In the same Patent Specification† Mr. Willis describes another form of relief pallet which is worthy of notice here. We shall again use the words of the Specification. Fig. CLXXII shows another "arrangement for neutralizing the pressure of the air in the wind-chest [pallet-box] upon the valve. In this example, the valve C, instead of being scooped out, consists simply of a hollow frame packed with leather, covered at its back with a flexible diaphragm D. A cross bar A, connected to the sides of the valve frame, is applied to receive the pressure of the closing spring. Pendent from the top of the groove or channel B are rods which carry a curved board E that performs the office of the grating in the first described

*Mr. Willis was under a misconception, we venture to think, when he wrote these words, and as he doubtless discovered later in practice. The pressure of the air being the same on both sides of the leather packing it will not affect or inflate it in any manner. The inflation will only take place when the valve is entirely closed.

†English Letters Patent, No. 2508, dated 8th October, 1861. Sealed 25th March, 1862.

arrangement, and takes the pressure of the greater portion of the flexible diaphragm. The valve, therefore, as it is pulled down, will offer a resistance equal only to the closing spring, and the pressure of the air on that portion of the valve covering not resting on the board E, and when this is overcome the valve will readily open to the full extent." This construction of pallet can only be conveniently adopted for the bass and tenor grooves of large manual wind-chests, and for those of pedal wind-chests generally.

Although it may not, strictly speaking, be considered a relief pallet, there is another ingenious contrivance invented by Mr. Willis for the purpose of reducing to some extent the pressure of the air, or the first resistance, on opening large pallets. This simple contrivance, which is illustrated in Fig. CLXXIII., is included in the Patent above mentioned, where it is thus described: "Attached to the

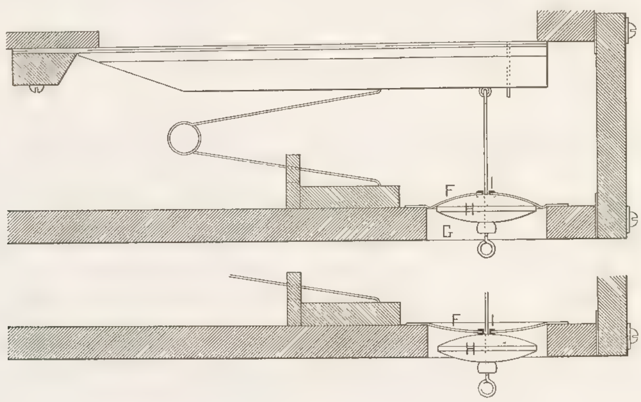


Fig. CLXXIII.

board inclosing and forming the wind-chest [pallet-box] is a flexible air-tight diaphragm F which covers the hole G in the bottom board; through this hole and through the diaphragm the pull-down wire passes instead of through the usual brass plate or purse. The diaphragm F is secured on the inside of the wind-chest in such a manner as to enable the compressed air therein to expand it in the form of a sack, and thereby assist in pulling open the valve; this diaphragm I back by a convex disc H, or its equivalent, fixed by an adjustable nut upon the pull-down wire. When the valve is shut this disc serves to sustain the flexible diaphragm against the pressure of the air, and the pressure of the air on the valve will be in great part neutralized." In this position the air is pressing the valve or pallet upward against its bed, and the diaphragm downward against the disc fixed on the pull-down wire; the pressure on the pallet is, accordingly, neutralized over an effective surface equal to the free area of the diaphragm. The instant the pallet is drawn from its seat all local pressure from the wind ceases to affect it; but the pressure continues on the diaphragm, aiding the action until the disc descends

below its influence, as indicated in the lower diagram. Mr. Willis concludes his description thus: "Sometimes it may be necessary to bush the center of the diaphragm by the insertion therein of a kind of metallic eyelet hole for the purpose of allowing the pull-down to work beyond and through the sack, in which case the disc will leave the sack, and only return when the pressure of air upon the valve requires counteracting." This eyelet is indicated at I in Fig. CLXXIII.

We may now direct attention to certain lever arrangements, applied to pallets for the purpose of lightening the manual touch, especially at the instant of opening them against the pressure of the air in the pallet-box. The first of these arrangements is shown in Fig. CLXXIV. and is apparently a German invention. As it is accurately and clearly detailed in the accompanying illustration, it is only necessary to touch briefly on its construction. A is the pallet, of the ordinary solid form, kept closed by the spring B. The pull-down wire C, after passing through the brass plate in the bottom of the pallet-box, is linked by a piece of hard leather to the tapped-wire D, which passes through the two levers E and F, and is brought to a bearing against both by buttons. G is the pull-down tracker connected with

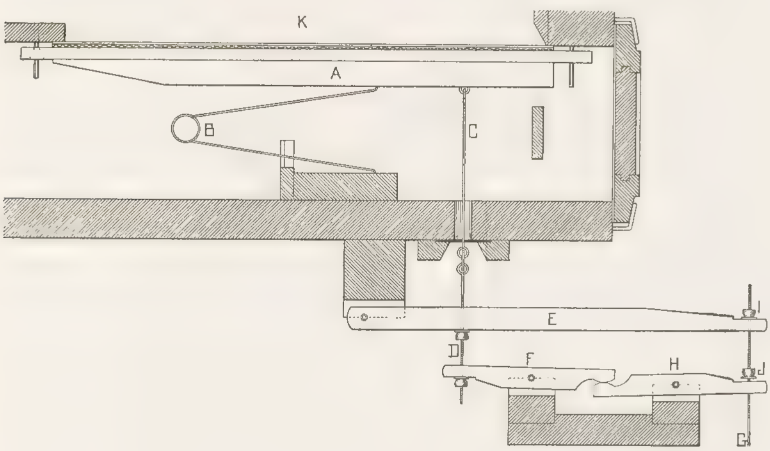


Fig. CLXXIV.

the key action, the tapped-wire of which passes through the free end of the long lever E and the small rocking lever or backfall H. It will be observed that while the button I rests on the lever E, the lower button J is a short distance (say about one sixteenth of an inch) from the lever H. The operation of the appliance may be thus described: On first touching the key the tracker G lowers the free end of the long lever E, and, with a leverage of three to one, easily draws the pallet from its bed, and allows the compressed air to rush into the wind-chest groove K. There is no longer any upward pressure on the pallet save that exerted by the spring B; so the depression of the key immediately brings the equal action of the rocking levers H and F into play, and the pallet is pulled down with ease to the full extent

required. This appliance can be used throughout the compass of the wind-chest, and when carefully made and adjusted to a balanced action gives a light and elastic touch.

The second lever arrangement, illustrated in Fig. CLXXV., is much simpler than the preceding, and has the advantage of being inclosed, and protected from dust, damp, and injury, within the pallet-box. The construction and action of this appliance may be described as follows: A is the pallet, of the ordinary solid form, faced with felt and leather, and hinged on a tail pin. This pallet is held against its bed by the main spring B. C is the pull-down wire, connected with the key action at its lower end, and with a small lever D at its upper end. This lever rests at one end against the fulcrum bar or block E; this end being slotted and held in position

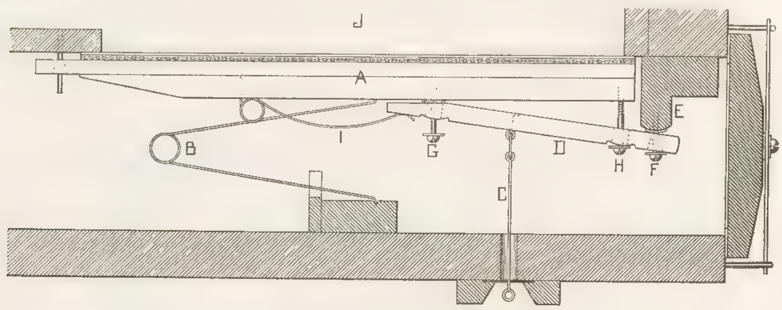


Fig. CLXXV.

by the screw F. Two screws G and H are inserted in the under side of the pallet, passing easily through two slots in the lever, as indicated by dotted lines. The small spring I, fixed to the pallet, is sufficiently strong to recover the lever and aid the key action. The drawing represents the appliance at rest, with the pallet closed. On slightly depressing the manual key, the lever D is pulled down, and as it bears tightly on the head of the screw H it readily overcomes the resistance caused by the condensed air and the pallet-spring, drawing the pallet sufficiently open to give the air access to the groove J. As soon as the free end of the lever reaches the head of the second screw G the quick action commences and the pallet is immediately opened to its full extent. On releasing the key the pallet is closed by its spring, and the lever instantly resumes the position shown in the illustration.

One other arrangement for the purpose of neutralizing to a great extent the pressure of the condensed air upon the closed pallet may be illustrated and briefly described, seeing that it introduces a device not met with in any of the appliances previously noticed. The arrangement will be readily understood on referring to the accompanying illustration, Fig. CLXXVI., which shows Side and End Views of a single pallet and its attendant details. The pallet A is of ordinary solid form, hinged on the tail-pin B, and held in position by the front wire C which passes freely through the fork in the nose of the pallet. The pallet is faced with

felt and soft leather in the usual way; and is pressed firmly against the wind-chest bars, etc., by the spring D, which has its underbearing on the bridge bar E. Secured against the bottom board F of the pallet-box is the small bellows G which is employed to neutralize to a large extent the pressure of the condensed wind on the closed pallet, leaving little more than the full force of the spring D to be overcome by the key action. This bellows is leathered on its under side, and is held air-tight against the bottom board F by small metal projections pressed by two screws, as shown. While it is air-tight toward the inside of the pallet-box, its interior is in free communication with the external air through an opening cut in the bottom board, and a corresponding one in the bellows, as indicated by the dotted lines I in both Views. The upper board of the bellows is linked to the pallet by the wire H; and directly below this, the pull-down wire J is attached to the same board in the interior of the bellows, and passes down through the opening I before mentioned. This pull-down is attached to the key action.

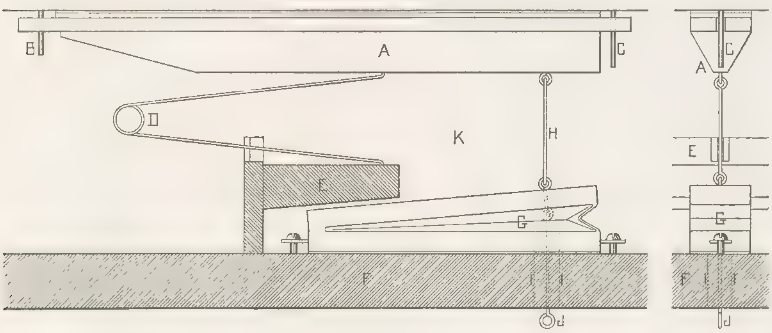


Fig. CLXXVI.

The operation of this device is extremely simple. The condensed air in the pallet-box K exerts a pressure upward against the closed pallet A, and downward against the expanded bellows G, proportionate to their respective surface measurements. The bellows is so proportioned as to give a very small excess of effective surface to the pallet, which in addition to this slight wind pressure is held firmly against its seat by the pallet-spring D. Accordingly the key action has little more to do in opening the pallet when the organ wind is in than when it is out. Very little beyond the strength of the spring has to be overcome in first drawing the pallet from its seat; and immediately it is open all local pressure ceases, so far as it is concerned, while the bellows at that instant comes into active operation, substantially aiding the key action against the increasing strain of the closing spring. It is advisable to take every precaution so far as the bellows is concerned to prevent escape of the condensed air; its leather folds should be partly covered on the inside with thin writing paper, care being taken not to cripple the flexibility of the folds. An air-tight fabric may be used instead of leather.

This Chapter would not be complete without some notice being taken of certain Patents connected with the other forms of relief pallets. We shall, however, confine our notes to the descriptions given by their inventors, omitting illustrations. Those of our readers who desire full information may consult the Patent Specifications, the respective dates and numbers of which we give.

In his Patent dated 1851, No. 13,538, Mr. Henry Willis describes a valve of large size, which he principally used for the Pedal Organ, thus: "This valve is provided with two rectangular openings for the passage of the wind, and they are each supplied with a grating to support the valve covers, which are composed of flexible leather, or of vulcanized sheet rubber covered with a woven fabric on one side only to prevent its stretching. The peculiarity of this valve is that it is opened by the rolling up of the valve cover, by which means the great resistance offered by the pressure of the wind in the air chamber to the opening of large valves, hitherto so detrimental to developing the capabilities of both the organ builder and the performer, is counteracted; and thus the builder is enabled to increase the capacity of the instrument without the fear of its being beyond the muscular power of the player to bring the various stops into use as they may be required for the efficient performance of any given piece of music." The pieces of flexible material, forming the valve covers, are affixed at one edge to the valve seat, and at their other edge to a roller. The diameter of this roller is enlarged in its center, and to this enlarged part is attached a band or tape, which is connected by a wire with the tracker or connecting rod from the pedal key. By the depression of the key the tape is drawn in one direction, while the roller is caused to move in the opposite direction, uncovering the valve openings. In order to bring back the roller and cover the valve immediately the pressure of the key is removed, the extremities of the roller are made of less diameter than the part on which the valve cover is wound, and to these parts tapes are attached, which are connected at their opposite ends with coiled springs secured by pins to a stationary bar. The action of this elastic attachment is that it will yield to the pull of the central tape, connected with the key action, and as soon as the pressure of the key ceases it will cause the roller to return and cover the openings in the valve. In order to understand this action it should be remembered that the effect of giving the roller three different diameters, and attaching it as described, is to make it a rolling lever having its fulcrum in the line of the valve cover; the drag, therefore, upon it by the different tapes, although they are both in the same direction, will, from the fact of being on opposite sides of the fulcrum, cause the roller to move in opposite direction. For the purpose of rendering the above description intelligible in the absence of drawings, we have taken some liberties with the text of the Specification.

Mr. Willis continues: "I sometimes adopt the following modification, whereby I am enabled to produce a very efficacious, secure, and noiseless valve:—In place of a roller I attach the valve cover to a piece of wood, or other light substance, which is a segment of a much larger cylinder than the roller, and apply to the middle thereof a still larger segment to which the central tape is secured, as in the former case; when, therefore, a drag is put on this tape to open the valve

the segment will rock and lift up the cover in like manner to the roller. A similar means to that above mentioned is also employed for returning the cover to the valve seat."

In his Patent Specification,* Mr. Henry Augustin Ornano Mackenzie describes an appliance connected with wind-chest pallets thus: "My invention relates to apparatus for opening the pallets of Organs as required with increased facility, and consists in adapting and applying between the ordinary pull-down wire connected to the pallet and the ordinary tracker leading from the key a pair of levers or links, so formed and arranged as to give the key increased acting power over the pallet in order to open it, and to reduce that power rapidly as the pallet continues to open and the resistance to its opening decreases. For this purpose the pull-down wire is connected to a balanced-lever, and the tracker to another balanced-lever by suitable links. These two levers overlap each other and are adapted to work together in the manner hereinafter stated. When the pallet is closed the extreme end of the lever connected to the pull-down wire holds up the lever connected to the tracker, so that the end of the last-mentioned lever is a short distance, say, one sixteenth of an inch (as may be required) from the first-mentioned lever. If the tracker be now pulled down it will draw both levers with it, and the power exerted will be that due to the combined action of both levers, having a tendency to open the pallet, until the end of the tracker lever is brought in contact with the pull-down wire lever, at a point in a line with the connections of the two links with the levers. From this point the levers cease to act as levers, and the power exerted on the pull-down wire will simply correspond with that applied to the tracker."

In 1894 Messrs. William and Edward King patented a simple lever action for relieving the touch in connection with the ordinary slider and pallet wind-chest.† In their Specification they speak of their invention thus: "It is well known to those skilled in organ construction, that the wind pressure in the wind-chest and upon the pallets which admit the wind to the larger pipes of large and medium sized Organs is too great to be easily overcome by the pressure of the fingers on the keys, consequently the manipulation of such Organs is laborious and tiresome; and it is also well understood that the required pressure on a key of an Organ to actuate the pallet in the wind-chest, when under pressure, is the least when the pull-down wire is connected with the pallet at a point nearest to the actuated end. . . . The object of the present invention is to obtain such a construction of pipe organ action as will overcome the wind pressure on the pallet by a slight pressure of the finger on the key, and which will open the pallet fully with a limited range of movement in the pallet actuating mechanism.

"To this end the main feature of our invention embraces the combination with a pallet of a plurality of pull-down wires connected therewith at different distances from the actuated end of the pallet, and means for actuating the pull-down wires successively. A second feature embraces the combination with a pallet

* "Improvements in Organs." English Letters Patent, No. 696, dated March 16, 1871. Fully illustrated.

† "Action for Pipe Organs." United States Patent, No. 522,902, dated July 10, 1894. Illustrated.

and a plurality of pull-down wires connected therewith of a pivoted lever for actuating the pull-down wires, said wires being connected with the lever at different distances from the fulcrum."

The appliance consists of a lever pivoted at one end, through which two pull-downs are passed : one close to the pivot and the other near the free end. The pull-down adjoining the pivot is attached to the actuated end of the pallet, and its button presses against the under side of the lever. The other pull-down is attached to the pallet close to the pallet-spring, passes through the free end of the lever, and has its button slightly below the under side of the lever. The pull-down or tracker from the manual key acts on the lever between the pallet pull-downs. The action is as follows : When the key is depressed the pull-down between the tracker and the pivot or fulcrum of the lever is slightly drawn down, and the pallet is sufficiently opened to remove all pressure from its surface. The lever, still falling, now acts on the other pull-down, and easily opens the pallet to its full extent.

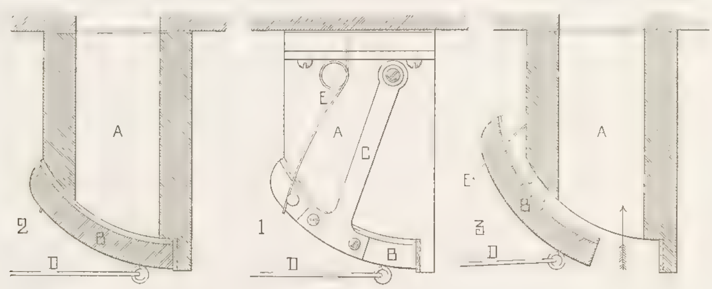


Fig. CLXXVII.

In the year 1841 a silver medal was awarded by the Society of Arts to Mr. Hill, of London, for the invention of a valve or pallet suitable for the supply of wind to the larger pipes of the Pedal Organ. This, known as the "box-pallet," is constructed after the manner shown in the accompanying illustration, Fig. CLXXVII. The body of the contrivance is in the form of a narrow box A of any suitable length, the lower part of which is shaped to the segment of a circle, to which is accurately fitted a movable bottom or valve B, covered with pallet-leather on its inner surface, and held in position by an arm C at each end. The motion imparted by these arms is eccentric to the curvature of the valve B ; so that when the wire D is pulled by the key action, the valve is drawn sideways without experiencing any perceptible pressure from the condensed air. The only portion of the valve directly acted upon is its outer edge, and the slightest movement of the valve does away with all local pressure. The valve is returned to its seat by a spring E at each end. The End View, 1, and the Section, 2, show the valve closed ; while the Section, 3, shows the valve open. The upper part of the box communicates either with a groove of the wind-chest or directly with the foot of a large pipe.

CHAPTER XXVI.

THE PNEUMATIC LEVER.

TO about the end of the first quarter of the nineteenth century, organ builders appear to have made no decided attempts to improve or depart from the primitive mechanism belonging to the key action of the Organ. In the great work by Dom Bedos—the first practical treatise of any importance on organ construction—we find nothing but a simple action, in the form of a combination of squares, backfalls, rollers, trackers, and stickers, described and illustrated; and from the time of its publication (1766-1788) up to the period above mentioned no radical alterations were made in the mechanism of the Organ. In this primitive key action all the mechanical conditions were against the attainment of lightness and elasticity of touch; and, accordingly, in large instruments the claviers were heavy and fatiguing to play. It is somewhat surprising that the German organ builders of the eighteenth century—the epoch during which so many important instruments were constructed by them—did not turn their attention to the improvement of the mechanical portion of the Organ. They appear to have rested quite content with the mechanism as they found it in earlier works; and directed their attention to the development of the tonal forces of the instrument. It is well for modern organ-building that they did not neglect this all-important branch of their art; for in recent times it has been proved quite possible to have too much mechanism and too little musical tone in the Organ.

It is true that something had been essayed in the direction of relief-pallets, or lever movements, to overcome the initial strain of the key action; but in cases where the pallets were large, and the use of the several manual couplers multiplied them on a single clavier to a serious extent, the touch became too heavy to be easily overcome by the ordinary force of the fingers on the keys. It became, accordingly, obvious that some other agent was necessary to reduce this excessive

strain in the action; and the breath of the Organ itself supplied to the inventive mind the agent sought for. It was always present when the Organ was in use, and was easily controlled and of considerable power when properly applied.

The first known essay toward relieving the manual key action through pneumatic agency was made by Joseph Booth, organ builder, of Wakefield, Yorkshire, and was introduced in the Organ constructed by him, in 1827, for the church at Attercliffe, near Sheffield. In this instrument, he planted the lower pipes of the OPEN DIAPASON of the GGG Great Organ on a special wind-chest, and attached the pull-down of each pallet therein to a small circular bellows, which expanding downward, by the force of compressed air, drew the pallet open. The compressed air was admitted and exhausted by the ordinary key action of the Great Organ. The circular bellows here used were called by the inventor "puffs." In the year 1830, Sebastian Érard exhibited in Paris an appliance of a somewhat similar character, which he called the "light touch valve"; but with the construction of this we are unacquainted.

We now come, in the order of time, to what were the early forms of the appliance since known as the pneumatic lever. In the year 1835, David Hamilton, of Edinburgh, Organ Builder to the Queen for Scotland, invented a pneumatic appliance "for relieving the weight of the touch of large instruments", applying it, in that year, to the Organ in St. John's Episcopal Church, at Edinburgh. In 1839, he brought his invention before a meeting of the British Association at Birmingham, reading a description and exhibiting a model of it.* In Fig. CLXXVIII. is given a Section showing the construction of the model alluded to. While different in form and in disposition of parts, the principle of its construction and the mode of its action are essentially the same as found in the most perfect form of the pressure pneumatic lever of to-day. A is the chamber charged with compressed air from the organ bellows; and B is a smaller chamber into which the compressed air is admitted when the small pallet C is drawn down by the wire D, which is connected with a manual key. The chamber B has three openings: one over the pallet C; one to the external air at E; and one for the reception of the conveyance F. Above the circular opening E is placed a disc-valve G, connected by a wire with the pallet C, as indicated. H is a small power-bellows connected with the Chamber B by the conveyance F. Above the apparatus just described is shown a section of a small wind-chest. Its lower chamber I is the pallet-box, charged with compressed air from the bellows, while at J is indicated one of the grooves of the chest on which the pipes are planted. One pipe only was used in the model, as indicated, so as to render the usual slider construction unnecessary. A wind-chest pallet of the ordinary form covers the opening to the groove at K; and this is connected with

* In a brochure issued by Mr. David Hamilton, in 1851, we find the following: "Many years ago he [Mr. Hamilton] discovered a new principle in mechanism, which he applied for relieving the weight of the touch of large instruments. This invention he added to the Organ in St. John's Episcopal Church, Edinburgh, in 1835, and a paper was read at a meeting of the British Association at Birmingham in 1839, explanatory of a Model of it which he exhibited. He afterwards found this identical invention (in all its details the same as his Model) applied in the Grand Organ of the Church of St. Denis, and in that of the Madeleine Church in Paris, under the name of the 'Pneumatic Lever,' and which he has reason to believe was taken from his Model, as its first introduction in Paris was subsequent to the date of the exhibition at Birmingham."

the bottom-board of the power-bellows by the pull-down wires L. The other details introduced require no description. The action of the apparatus is very simple. On the depression of the manual key, the wire D pulls down the pallet C and the disc-valve G, admitting the compressed air into the chamber B, and through the conveyance to the interior of the power-bellows H. The bellows instantly becomes inflated, pulling down the pallet K, and causing the pipe to speak. On releasing the key, the pallet C closes and the disc-valve G opens, allowing the compressed

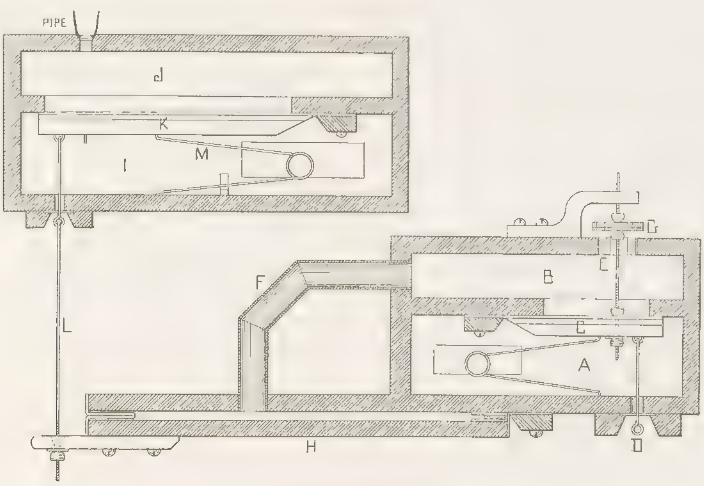


Fig. CLXXVIII.

air in the bellows H to escape through the chamber B and the opening E into the external air. As the bellows collapses, the pallet K closes by the force of the pallet-spring M, and the pipe is silenced.

About the same period Mr. Charles Spackman Barker, of Bath, was directing his attention to an appliance on similar lines and for the same purpose. He is said to have first experimented with a small cylinder and piston, but abandoned them in favor of the power-bellows, finding the former too sluggish and unreliable, as might be expected. The following extract from notes written by Mr. Barker, respecting his invention, are of considerable interest to the student of the art of organ-building:

"It was in 1832 that Mr. Barker, then established as an organ builder in Bath —his native city—was led to reflect on the serious inconvenience arising from the extreme heaviness of touch in all large Organs, and as more particularly exemplified in the one then but recently constructed for York Cathedral. His persevering studies having revealed to him an efficacious remedy for this defect, by the invention of what has since been called the pneumatic lever, he wrote, in 1833, to Dr. Camidge, then organist of the Cathedral, announcing his discovery, and begging to be allowed to give a proof of its efficacy, by applying it in a temporary way to one

of the heaviest keys of the Organ. Dr. Camidge in his reply wrote: 'To such an instrument as ours it (*i. e.*, the discovery) would most certainly be very important, where four Organs have to be played occasionally by ONE set of keys, and I should be most happy to recommend its adoption. Mr. Hill, of the late firm of Elliot & Hill, has erected our Organ, and, I assure you, the playing it is no sinecure; on the other hand, it is most laborious work to go through a grand chorus or last voluntary with the whole power of the instrument. Such a difficult touch as that of York Cathedral Organ is doubtless sufficient to paralyse the efforts of most men, I assure you. I, with all the energy I rally about me, am sometimes inclined to make a full stop from actual fatigue in a very short time after the commencement of a full piece.' Notwithstanding Dr. Camidge's wish and recommendation, financial difficulties stood in the way of Mr. Barker's invention being adopted in York; nor was he more successful in his proposition for applying it to the Birmingham Organ, opened in 1834 or 1835. It was about this period that the eminent French builder M. Cavaillé was occupied in building a colossal Organ for the Royal Church of St. Denis, near Paris, and it was already sufficiently advanced to convince Mr. Barker that, for heaviness of touch, it would rival or even surpass the York Minster and Birmingham Organs in their then conditions; indeed, it might have been fairly questioned, whether any organist of acknowledged talent would risk his reputation by attempting to play it. Mr. Barker heard from a friend who visited the Continent occasionally that such an instrument was building, and Mr. Barker wrote immediately to M. Cavaillé to propose the introduction of his pneumatic lever, accompanying his letter with a certificate from his since lamented friend, Mr. Merrick, who had played on a small instrument Mr. Barker had fitted up for demonstration, each key of which presented a resistance of several pounds. This was in 1837. M. Cavaillé replied, engaging Mr. Barker to go over to France, and examine the possibility of applying his invention to the magnificent Organ in question. Mr. Barker visited Paris, and the application was decided on, under his immediate superintendence. However, in order to establish his priority as inventor, and protect at the same time his interests, previous to doing anything more in the matter, he took out, in 1839, a French patent, and soon after the pneumatic lever was applied with the greatest success, and for the first time, to the Saint-Denis Organ.* After having passed an agreement with M. Cavaillé to grant him

* M. J. Adrien de La Fage, in his "Rapport à la Société Libre des Beaux-Arts sur le Grand Orgue de Saint-Denis" (1844) says: "Une découverte récente appliquée pour la première fois à l'orgue de Saint-Denis, mérite d'être mentionnée avec quelque développement. Nous voulons parler de l'appareil connu sous le nom de *machine Barker*, et que M. Hamel a nommé *levier pneumatique*. Cette invention due à M. Barker, mécanicien anglais, a pour objet de rendre les claviers de l'orgue le plus considérable aussi faciles et aussi doux que ceux des pianos les plus parfaits.

"Les claviers de l'orgue sont, comme on le sait, en général durs à toucher, et la résistance que les touches opposent aux doigts est d'autant plus grande que les jeux de l'orgue sont plus nombreux. Cette résistance naît de la pression de l'air sur les soupapes mises en action par les touches des claviers; elle semblait en conséquence inhérente à la constitution même de l'instrument. Malgré toute la précision que la mécanique a pu acquérir en ces derniers temps, ses procédés ordinaires étaient tout-à-fait impuissants pour remédier d'une manière efficace à cette dureté des claviers qui, comme il est aisé de la comprendre devient bien plus sensible encore lors des *accouplements*, c'est-à-dire quand par l'action d'un clavier unique on en fait mouvoir d'autres.

"Ayant reconnu l'insuffisance des moyens employés jusqu'alors, M. Barker eut l'idée de se servir du principe de la *détente des gaz* qui, dans ces derniers temps, a donné naissance à ces moteurs extraordinaires

licence, under Mr. Barker's patent, as he might require, and which led to its application to the Organs in St-Roch, La Madeleine, St-Vincent de Paul, etc., Mr. Barker's connection with M. Cavaillé ceased, and he then was led to undertake the direction of a large organ-building establishment recently formed in Paris, under the name of Dublaine and Callinet, where he had frequent opportunities of introducing his invention. This company having been dissolved about 1845, Mr. Barker undertook to carry on the concern for a M. Ducroquet, a capitalist who had purchased it, and built for him, among other important instruments, that of St-Eustache, as also the small but very complete Organ which appeared in the French department of the London Universal Exhibition of 1851, and for which M. Ducroquet received, in addition to the English prize medal, his nomination of Chevalier of the Legion of Honor."

In the Exhibition instrument just alluded to Mr. Barker introduced the pneumatic lever to the manual claviers in a most complete form, and commanding the unison, octave, and sub couplers. By the year 1851 English organ builders had begun to realize the value of the pneumatic lever. In that year Mr. Henry Willis, the distinguished English builder, took out the first English patent for a pneumatic lever,* the field having been very unwisely left open by Barker. In his Specification it is described as "a pneumatic lever and its appendages, with my improvement applied thereto." It is unnecessary to illustrate or describe this early form of lever, as we treat of a more satisfactory treatment farther on. In the London Exhibition of 1851 Mr. Willis showed an Organ in which both the clavier and draw-stop actions were pneumatic, but not the couplers; and Mr. Hill exhibited an instrument in which the draw-stop action was pneumatic.

connus sous le nom de *machines à vapeur;* mais au lieu de la vapeur d'eau, il s'efforça d'obtenir le même effet au moyen de l'air comprimé. L'appareil que l'auteur a imaginé pour tenir lieu du cylindre des machines à vapeur et en remplir les fonctions, consiste simplement en un petit soufflet aboutissant à chaque touche, qui se gonfle et se dégonfle instantanément par l'introduction ou l'échappement de l'air au moyen de deux petites soupapes mues alternativement par la double action de la touche, qui n'éprouve ainsi aucune résistance étrangère. La puissance d'action de cette machine naît, comme on voit, de la force élastique de l'air qui la met en jeu, multipliée par la surface de la paroi mobile du récipient; elle peut en conséquence augmenter à volonté en faisant varier ces deux conditions.

"Cette découverte amenait une révolution dans la mécanique de l'orgue ; son auteur, M. Barker, avait cherché à la faire adopter en Angleterre où il avait été découragé par tous les facteurs d'orgues auxquels il s'était efforcé d'en faire comprendre les avantages. Ayant pris le parti de venir en France et de s'y faire breveter, il trouva dans M. Aristide Cavaillé l'appui éclairé qu'exigeait la mise en pratique de son invention; ce dernier dut, conjointement avec l'auteur, se livrer à des expériences ayant pour but d'obtenir une bonne disposition de l'appareil, et les meilleures conditions de durée et de solidité ; ce fut seulement alors que la première application en fut faite à l'orgue de Saint-Denis.

"Comme toutes les bonnes idées, cette innovation avait d'abord eu ses détracteurs; on objectait la complication de l'appareil, le défaut de solidité et le manque de prestesse dans le toucher; enfin, l'on s'avisa même que la docilité des claviers de l'orgue aurait l'inconvénient d'habituer les organistes à jouer trop vite, comme si la douceur du clavier dans le piano empêchait les pianistes de jouer aussi lentement qu'il leur convient. Toutes les objections tombèrent lorsque l'on put observer l'effet de l'appareil à l'orgue de Saint-Denis; chacun dut admirer l'extrême douceur des claviers et remarquer que leur réunion, au moyen des pédales d'appel, n'augmente en rien la résistance, quel que soit le nombre des claviers mis en jeu simultanément. On n'y vit plus dès lors qu'une ressource nouvelle pour l'exécution, et l'on eut à féliciter M. Cavaillé du bon jugement qui lui avait fait sentir de prime abord le mérite et les avantages d'une découverte que d'autres facteurs avaient repoussée avec dédain et dont patronage a déterminé le succès."

*English Letters Patent, No. 13,538, dated February 28, 1851.

In the Paris Exhibition of 1855 Mr. Barker appeared as an exhibitor independently of M. Ducroquet, for whom he had constructed, as a last work, an Organ of twenty speaking stops, with three manual divisions and separate pedal department, for the Exposition. In this notable instrument the pneumatic lever was admirably applied, enabling the builder to place the powerful reed stops of the Great Organ in the Swell Organ box, thereby securing unusual flexibility and powers of expression in the Great division. The special merits of this instrument were recognized by the jury, and at the close of the Exposition Mr. Barker, as the inventor and practical builder, was awarded a first class medal, and nominated Chevalier of the Legion of Honor.

Although Barker's name will always be associated with the pneumatic lever, it is questionable if he is entitled to the full honor of having invented it. It has been shown that Booth, of Wakefield, had introduced, in 1827, an appliance which contained the germ of the pneumatic lever; and that Hamilton, of Edinburgh, had used a pneumatic lever as early as 1835; and had exhibited a model at Birmingham in the year Barker took out his French patent. These facts should not be ignored.

We shall now describe certain types of the pneumatic lever, which practically cover all the principles involved and treatments followed in the construction of the appliance by different builders. As MM. Cavaillé-Coll were the first builders to put the pneumatic lever to a full practical test in an important Organ, we may select the appliance as generally made by them for immediate description. This form appears in several instruments made by M. Aristide Cavaillé-Coll, including the Organ in the Albert Hall, at Sheffield. In Fig. CLXXIX. are given a Section and Top View of this pneumatic lever. The lower portion of the appliance consists of three chambers fitted with valves; and the upper portion is a long and narrow power-bellows, forming the lever. The chamber A is continuous, and of sufficient length to supply as many power-bellows as may be placed in a single row, rarely exceeding eleven in number. This chamber is charged with compressed air from a special high-pressure bellows, through a vertical wind-trunk, indicated at T in the Top View; it communicates with the middle chamber B by the circular opening C which is opened and closed by the conical valve D. The chamber B is partitioned for each power-bellows, as shown in the Top View, and has an oblong opening at E, which allows the compressed air to pass into the power-bellows G through the circular opening in its bottom-board, at F. The third chamber H is also partitioned, and has two openings: one at I, communicating with the power-bellows, and the other at K, communicating with the external air. The two conical valves D and L are secured by leather buttons to the strong horizontal wire M, which is supported in position by the partition between the chambers B and H, through which it passes easily and practically air-tight, by the carrier N and, externally, by the square O. The wire also passes through the leather purse P, which prevents the condensed air in A from escaping in that direction. The conical valves are so adjusted on the wire as to open and close the openings C and K simultaneously, the distance traveled being, as a general rule, equal to the depth of the manual key touch, say 3/8 inch. The valves

are of light wood, turned, and faced with thin leather, and bed closely against the smooth edges of their respective openings. The square O is connected with the manual key by the tracker R, and the key action is returned by the spring Q, operating on the free end of the valve wire, as indicated. The power-bellows G is made of two boards, hinged at one end, and connected in wedge-form by folds of strained sheepskin of sufficient thickness to withstand the pressure

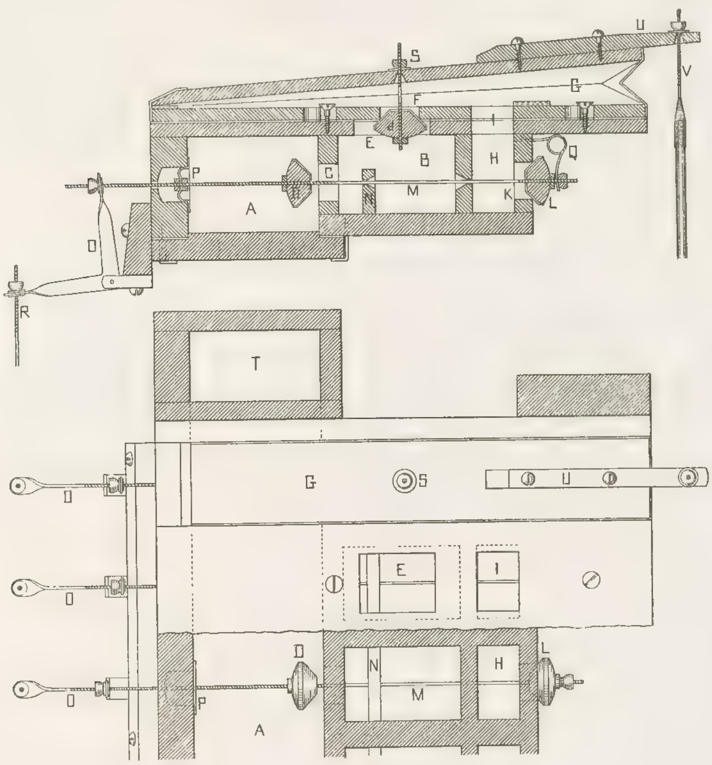


Fig. CLXXIX.

of the internal compressed air without impairing perfect freedom of action in expanding and collapsing. The bellows is furnished with a conical check-valve J, suspended from its top-board directly under the circular opening F in its bottom-board. This valve regulates the action of the bellows by cutting off the supply of compressed air at the desired point. The adjustment is made by the external button S. The arm U, which projects from the front end of the top-board, is connected with the pallet of a distant wind-chest by a system of trackers, squares, etc., the immediate attachment being made by the tracker V.

The operation of this pneumatic lever is very simple. When at rest, the valves are in positions the reverse of those shown in the illustration: the valve D rests against the circular opening C, cutting off all communication between the compressed air chamber A and the middle chamber B; the check-valve J is lowered, as the power-bellows collapses, leaving the opening F free for the passage of air; and the valve L is moved outward, leaving the opening K unclosed. Now, when the manual key is depressed by the performer, the square O is moved so as to pull outward the wire M, and the valves D and L take the positions indicated in the Section. The compressed air instantly rushes through the chamber B up into the power-bellows, inflating it and setting in motion the heavy action between it and the distant wind-chest. The check-valve J takes the position shown, holding the bellows at its proper extension. So long as the key is held down the pneumatic lever remains in this condition; but the instant the key is released the valve D closes and shuts off the compressed air from the chamber B, while the valve L opens and allows the compressed air in the power-bellows to escape through the chamber H and the opening K into the external air. The bellows sharply collapses by the downward pull of the action connected with the tracker V.

This pneumatic lever differs considerably from the original form patented by Barker, and is certainly an improvement thereon. In Barker's lever the continuous compressed air chamber resembled the pallet-box of an ordinary wind-chest, being furnished with as many small hinged pallets as there were levers placed over it. The upper portion was in the form of a long, narrow box, having the end which was fixed to the compressed air chamber pierced with an oblong opening in its upper side. This opening, for the escape of the condensed air from the power-bellows, was fitted, within the box, with a rocking valve, the free end of which was linked to the pallet below, so that when the latter was opened it closed the escape valve above. The power-bellows was fixed to the other end of the box and was expanded in an upward direction. Illustrations of Barker's pneumatic lever are given in Töpfer-Allihn's work "Die Theorie und Praxis des Orgelbaues." *

The pneumatic lever illustrated in Fig. CLXXIX. is introduced by Cavaillé-Coll in the Grand Organ of Saint-Sulpice for both upward and downward pulls: in the latter action the power-bellows is placed below the three chambers, and expands downward. In the Grand Organ of the Church of Saint-Vincent de Paul, Paris, Cavaillé-Coll has used a modified form of his pneumatic lever. In this the circular supply and escape valves work vertically from the opposite ends of a rocking lever. This was the action introduced in the Érard pneumatic lever.

In Fig. CLXXX. is given a Section of a simple pneumatic lever, invented by Messrs. Hill and Son, of London, and used by them in the Organ constructed under the author's direction for the Church of St. Margaret, Anfield, Liverpool. A is a horizontal wind-trunk to which is attached a series of the pneumatic levers. This trunk conveys the compressed air through the opening B to the chamber C of the lever-box. A circular opening at F connects the compressed air chamber

* "Atlas." Plate XXXVIII., Fig. 1. Edition published by Voigt, Weimar, 1888.

with the larger chamber G, through which the power-bellows is inflated and exhausted. This chamber has two openings: one in the bottom-board of the power-bellows, at K, through which the compressed air enters and leaves the bellows; and the other to the external air, at J, through which the compressed air escapes when the bellows collapses. In front of the box is supported the square O, the lower arm of which is connected with the manual key action by the tracker P. The upper arm carries the wire Q, which passes air-tight through the leather purse D, and is linked to the circular valve E by the wire bridge, as indicated. The valve E is of light wood, turned in the form shown, and faced with felt and soft pallet-leather. It is supported in position by the long wire H, which at one end passes through an eye formed in a wire fastened across the center of the circular opening F, and at the other end through the pivoted arm N. The wire also passes through a slot in the arm of the escape-valve I, which opens and closes the orifice J. The valve E is kept closed and the valve I open, as shown in the Section, by the pressure of

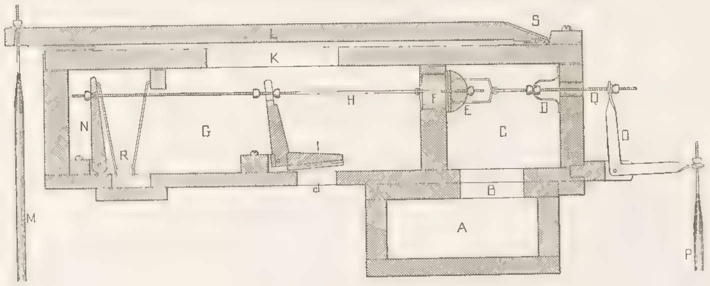


Fig. CLXXX.

the spring R on the arm N. Leather buttons, placed as indicated, keep all parts in their proper relative positions. L is the top-board of the power-bellows, hinged at S, and having a lug formed at T for the reception of the tapped-wire of the tracker M, which conveys its motion to the action connected with the wind-chest pallets, manual couplers, etc. On depressing a manual key, the tracker P is drawn down, the square O moved, the valve E is pulled away from the opening F, and the escape-valve I is closed: this action is instantly followed by a rush of compressed air through the openings F and K, and an inflation of the power-bellows. On releasing the key, the reverse action takes place: the supply of compressed air is shut off, and the valve I opens, allowing the compressed air in the chamber G and the power-bellows to escape. The top-board L immediately falls, and every part of the pneumatic lever resumes the position shown in the illustration.* This pneumatic lever is far from perfect, as will be realized when it is compared with the most approved form of the appliance, as patented by Mr. Henry Willis, and subsequently made by several other English builders. The chief imperfection of

* This illustration has been accurately made from a pneumatic lever presented by the late Mr. Thomas Hill to the author.

the Hill pneumatic lever is the absence of a check- or throttle-valve, the introduction of which was patented by Mr. Henry Willis in the year 1853, and of which no indication appeared in the pneumatic lever patented by him in 1851. All such levers not furnished with the throttle-valve in some form, have to strike against an external check, which controls the extent to which the power-bellows expands. However well the check is padded, an objectionable noise is caused by the smart blow of the top-board of the bellows against it.

Before proceeding to describe the pressure pneumatic lever in its most practical and convenient form, substantially as patented by Mr. Henry Willis in 1853,* we may direct attention to the improvements made thereon by Mr. Vincent Willis, patented in 1884.† We extract the following from the Specification:

"The present invention constitutes an improvement upon the pneumatic lever for which Letters Patent were granted to Henry Willis bearing date 14 November 1853, No. 2,634.

"In pneumatic levers as at present constructed and commonly used the supply and exhaust valves for admitting the air to, and discharging it from, the pneumatic lever are never entirely closed at the same time and are often both partly open at the same time, when in use. The result of this is a certain slowness of the lever in responding to the touch of the player, and a considerable waste of air which rushes uselessly through the pneumatic lever, prior to the complete closure of one or other of the valves.

"Now, the object of the present Invention is to obtain a more rapid attack, with consequently improved repetition and less noise of the working parts, and to this end the invention consists in the combination with the supply- and exhaust-valves in a pneumatic lever of any kind, of a lever or system of levers for operating the said valves, which valve-actuating lever is connected to, or influenced by, the pneumatic lever itself in such a manner that as the said pneumatic lever rises or falls or alters its position with the variation in the air pressure upon or within it, the fulcrum or operative position of the said valve-actuating lever is shifted or changed in anticipation of its counter or reverse movement, and that valve, whether supply or exhaust, which has just been opened by the action of the performer will, through the connection established between the valve-actuating lever and the pneumatic lever, be allowed instantaneously to close or reseat itself, thus enabling the use of separate throttle-valves in pneumatic levers to be dispensed with, and preventing the escape of much air that would under previously existing systems have been wasted.

"The Invention in its simplest form consists of a single lever or bar passing between push buttons on the stems of the supply- and exhaust-valves, one end of this valve lever being connected with the system by which the movement of the key is transmitted, and the other end of the valve lever being connected by a link rod, or its equivalent, with the pneumatic lever itself. This valve lever may be appropriately designated a 'floating' lever since the position of its fulcrum is constantly being shifted when in use by the opening and closing or change of position of the pneumatic lever, which lever in opening shifts the floating lever in such a manner as to allow one valve, say the air inlet valve, to close or reseat itself, and puts the said floating lever into such a position that it can operate immediately upon the other, or air outlet valve, when pressure on the key is removed and vice versâ.

"By substituting a double-acting or compound lever, one member of which has a shifting fulcrum, for the valve-actuating lever above described, the invention can be applied with

* "Improvements in the Construction of Organs"—English Letters Patent, No. 2,634, dated November 14, 1853. Illustrated.

† "Improvements in the Action of Keyboard Instruments, especially applicable to Organs"—English Letters Patent, No. 15,114, dated November 17, 1884. Fully illustrated.

all its advantages to pneumatic levers of ordinary construction, the essential feature of the invention consisting in shifting or changing the position of the valve actuating lever synchronously with the movement of the pneumatic lever itself, in anticipation or readiness for the next movement of the parts necessary for reversing the action of the pneumatic lever, and in so actuating the valves of a pneumatic lever, that immediately either of the valves has acted to inflate or exhaust the pneumatic lever, it shall reseat itself ; both valves then remaining completely or practically closed until the key and its system of connections is released from pressure or receives a fresh movement under the hands of the performer.

"This arrangement of pneumatic lever is applicable to instruments operated either by air pressure or exhaust, the position of the valves under exhaust being reversed and the relative position of parts being slightly modified. The preparation for reversal need not in all cases be entire, as the invention may be used in combination with the throttle-valve described in the specification of the patent above referred to."

While the peculiar treatments of the pneumatic lever above outlined are decidedly ingenious, they are too complicated and difficult in their construction to commend themselves for adoption. Nevertheless they illustrate a principle of action which deserves to be studied by the student of the art of organ-building.

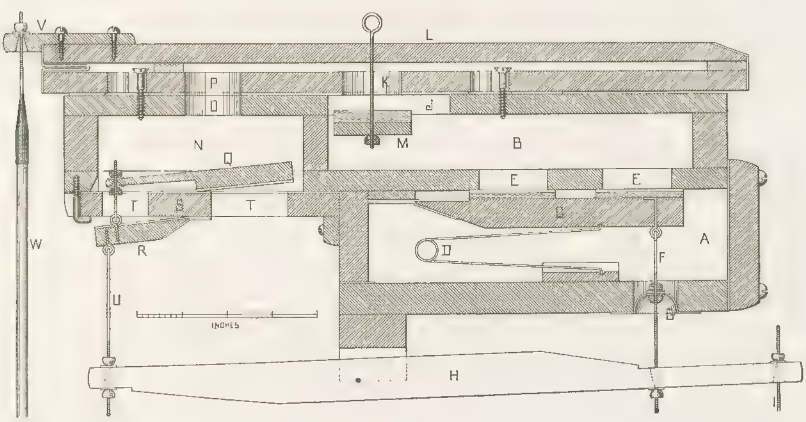


Fig. CLXXXI.

We now come to the pressure pneumatic lever in its most convenient and practical form of construction. The Longitudinal Section given in Fig. CLXXXI. is drawn from an actual pneumatic lever, which, while it is essentially similar to the form patented by Mr. H. Willis, presents some improvements in minor details. In the Section the appliance is indicated as at rest, with its power-bellows collapsed. At A is the cross-section of the horizontal compressed air chamber, on the upper side of which are attached, at regular intervals, the several levers. Between this chamber and the upper chamber B, in each lever, are two oblong openings E E, covered by the pallet C, faced with felt and leather, as indicated, and held against its seat by its hinge and the spring D. The pull-down wire F,

attached to the pallet, passes downward and air-tight through the leather purse G, and thence to the rocking lever H, which is connected with the manual key by the tracker I. At J is an oblong opening which allows the compressed air to pass from the chamber B, through the circular opening K, into the power-bellows above. Suspended by a strong tapped-wire from the top-board of the power-bellows L is the throttle- or check-valve M. This is of hardwood faced with thick and very springy felt. It controls the expansion of the power-bellows. The chamber N is also pierced with three oblong openings: that at O corresponding with the opening P in the bottom-board of the power-bellows, through which the compressed air is exhausted in action; and those at T T, in the movable bottom piece S, which allow the compressed air to escape to the external atmosphere. These latter openings are covered and uncovered by the two linked pallets Q and R, which conjointly form what Mr. Willis calls, in his earlier patent, a "compensating escape-valve." The pallets are in the positions shown when the lever is at rest, and are closed over the openings by the upward push of the rocking lever H and the wire U, when the manual key is pressed down. As the surface acted upon by the compressed air contained in the chamber N is larger in the case of the interior pallet Q than in that of the exterior pallet R, when both are closed, there is a slight and desirable pressure exerted in favor of closing them, and holding them air-tight when closed. To the free end of the top-board of the power-bellows L is attached the projecting arm V, carrying the tracker W which conveys the motion of the lever to the wind-chest and coupling actions.

When this pneumatic lever is set in motion by the depression of the connected manual key, the pallet C is drawn down, and the compensating escape-valve is closed by the movement of the rocking lever H. The compressed air in the chamber B rushes through the openings E E, filling the interior of the lever, and instantly expanding the power-bellows. As the top-board rises it carries with it the throttle-valve M, which, as it nears its seat, gradually contracts the air passage and diminishes the supply of air to the bellows. When the valve touches its seat, covering the opening K, it does so in a silent and comparatively slow manner, having the spring of its thick felt covering to prevent anything approaching a smart contact. On the manual key being released, the pallet-spring D recovers the key action, the condensed air is cut off from the chamber B, the escape-valves spring open, the power-bellows collapses under the downward pull of the wind-chest action, and the pneumatic lever comes to rest with all its parts in the relative positions indicated in Fig. CLXXXI.

In Fig. CLXXXI. the power-bellows is so placed as to exert an upward pull; but the whole appliance may be reversed, the power-bellows being underneath instead of above the air chambers. In this case the bellows, during inflation, will exert a downward pull. It will only be necessary to change the relative positions of the supply and exhaust chambers so that the pull-down tracker belonging to the key action may be at the back or hinged end of the power-bellows. The elongation of the rocking lever H will, of course, be at the escape-valve end and not at the supply-pallet end as shown in Fig. CLXXXI. This reversed position of the pneumatic lever is not to be recommended for several reasons, and should be

avoided when the action of the Organ can be arranged to admit of the upward pull of the lever.

In the year 1876, Mr. Charles Kenwick Kenelm Bishop, of London, patented an arrangement of pneumatic levers, of the class just described, whereby a great economy of space is secured.* The chief features of his arrangement consist in having only two tiers of horizontal valve-boxes, fitted with the necessary supply- and exhaust-valves, and in connecting with each horizontal valve-box two tiers of power-bellows—one resting on the valve-box and the other communicating therewith by a short, vertical wind-trunk or conveyance. In his Specification Mr. Bishop says: "The position of the pneumatic action in Organs is that in which all the most important mechanical movements are collected, and from whence they separate each to perform its separate function, and, therefore, it is the point where the utmost amount of accessibility is required. The space taken by the ordinary pneumatic action I am enabled to reduce to one-half or less by the use of the light form of pneumatic bellows described in a former Patent granted to me, and by employing two series of pneumatic bellows, one below the other, with each wind-chest [valve-box]. To allow of this, the valves commanding the passage of compressed air from the wind-chest into the bellows are arranged in a row. Every alternate valve controls the passage of air into the row of bellows nearest to the wind-chest, whilst the other valves control the passage of air into narrow passages which run parallel with the bellows, and at the back end rise up and lead to the several bellows of the upper row. By these means I am enabled to reduce the number of wind-chests from five, as is now usual [1876], to two, the wind-chests being placed one below the other in the ordinary manner, and thereby I obtain a very compact, portable, accessible, and less expensive arrangement than heretofore." In his Specification, Mr. Bishop describes the application of a tubular-pneumatic action to his arrangement of pneumatic levers.

All the pneumatic levers above described or alluded to are of the earlier class known as "pressure pneumatic levers"; that is, they obtain their power through the agency of high-pressure air admitted internally, while externally their power-bellows are surrounded by the ordinary atmosphere. Different degrees of power are obtained either by increasing the pressure of the air employed to inflate the power-bellows, or by enlarging the superficial dimensions of the power-bellows. In the most desirable treatment, however, a judicious balance is observed between the pressure used and the superficial dimensions of the power-bellows. The necessity, under prevailing conditions, of constructing the series of pneumatic levers so as to occupy the smallest possible space in the Organ, renders it necessary to keep the power-bellows as narrow as practicable, while, as a rule, a slight increase in length, always favorable to power, will not be inconvenient. This will be realized on glancing at the accompanying diagram, Fig. CLXXXII., which shows, in elevation, the arrangement of fifty-six pneumatic levers in five tiers, the tracker action of which lies within the boundaries of the manual clavier, and each lever being in line with the center of its corresponding key. When the levers are small—not

* English Letters Patent, No. 3210, dated 15th August, 1876. Fully illustrated.

exceeding 2¼ inches in width—they can be placed in five tiers; but when large and powerful ones are used, six or seven tiers may be required to keep the action within the clavier boundaries. The pneumatic levers indicated in the diagram are of the form used by M. Cavaillé-Coll, as before described. The ascending wind-trunk, which supplies all the horizontal condensed air chambers on which the power-bellows rest, is not shown in this diagram.

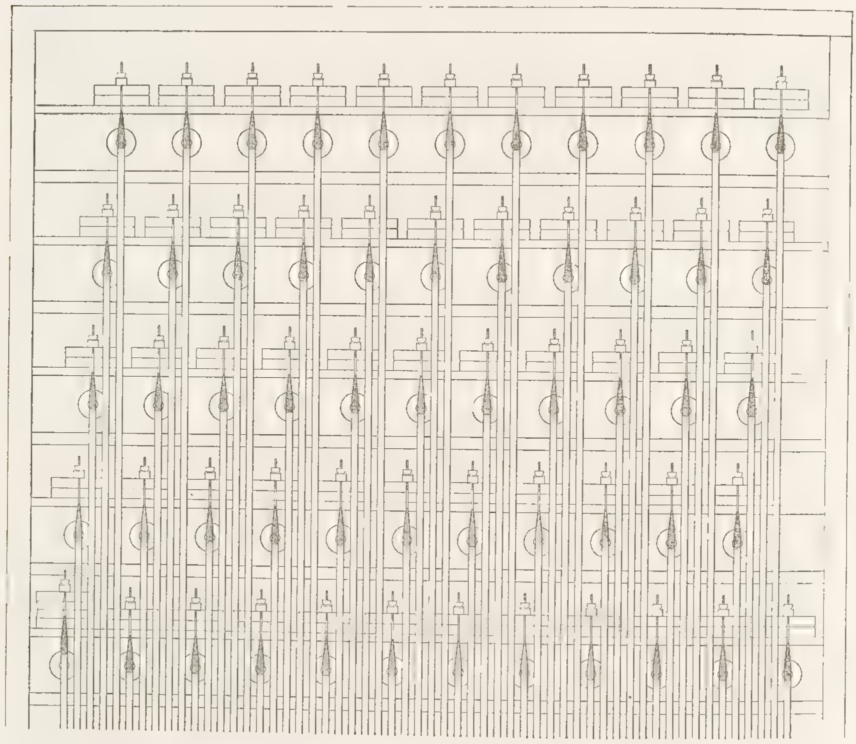


Fig. CLXXXII.

We come now to the consideration of the appliance known as the "exhaust pneumatic lever," a form introduced at a date much later than that which saw the pressure pneumatic lever perfected in England. At what date and by whom the principle of exhaust was first applied to the pneumatic lever we are unable to state with any degree of authority; but it certainly appears that the first practical and successful application is due to American ingenuity. We find the exhaust pneumatic lever introduced, in a patented form, in the Organ in the Cathedral of the

Incarnation, Garden City, L. I., constructed by Roosevelt in 1879–83. Speaking of this form the builder remarks: "The pneumatic lever is undoubtedly an appliance of inestimable value; in fact a really large Organ constructed in the ordinary manner would be altogether beyond the player's control if deprived of its aid. The difficulty, when it is applied to the manuals, is to obtain perfect repetition, but by a careful examination of the methods employed by Barker and Cavaillé-Coll of Paris, and Henry Willis of London, we have succeeded in producing an original form of pneumatic which surmounts every obstacle in this direction. We construct it on the exhaust system, thus overcoming all imperfections inseparable from inflation, besides which it is more rapid in its action and attended with less noise. By the avoidance of the ordinary wire passing through the wind-box, and the substitution of another device for transferring the power to the exterior thereof, we avoid all chance of leakage or 'sticking,' and reduce the friction to a minimum."

In the year 1888, Mr. Ira Bassett, of Chicago, Ill., took out Letters Patent for an improved exhaust pneumatic lever action, which is in several respects the most satisfactory, as it certainly is the most compact, ever invented. In Töpfer-Allihn's "Die Theorie und Praxis des Orgelbaues"—the leading German treatise on organ-building—an exhaust pneumatic lever action is illustrated, but in a very imperfect and unsatisfactory manner. This is constructed on a principle similar to Bassett's action, but is so inferior in all important details that further mention is unnecessary. It is given as the invention of Messrs. Hook & Hastings, of Boston, Mass. In the year 1887, Mr. George S. Hutchings, of Boston, took out a patent for an exhaust pneumatic lever action, constructed on similar lines, in which disc-valves are used instead of oblong, hinged pallets as in the preceding form.*

It will be sufficient to illustrate and describe the Roosevelt and Bassett appliances, for they practically cover the entire range of the treatments found in exhaust pneumatic levers.

In Fig. CLXXXIII. are given Longitudinal Sections of two Roosevelt levers, the upper one of which shows the power-bellows inflated and the appliance at rest; and the lower one the power-bellows collapsed, subsequent to the operation of the lever. Each horizontal set of power-bellows is arranged in a single chamber, which extends the entire width of the apparatus, and into which compressed air is admitted at one end from a vertical wind-trunk. The compressed-air chamber is shown at A: it has its bottom, top, and one side formed of wood, the other side being left open for the reception of the leather diaphragm B. The opening through which the compressed air enters from the vertical wind-trunk is indicated at C. At the end of each power-bellows a circular hole is bored through the bottom of the chamber, as at D; and from this other holes are bored at E, which establish a direct communication with the interior of the power-bellows F. Two disc-valves, formed of strong millboard faced with soft leather, I and J, are fastened by leather buttons on the vertical wire G, which is held in position by the guide H and the rocking lever K. When the appliance is at rest, the lower

* "Pneumatic Action for Organs." United States Patent, No. 375,356, dated December 27, 1887. The pneumatic lever illustrated in the Specification has no check-valve or other means of regulation, and is in other directions obviously imperfect.

valve J is held against its seat by the rocking lever and its spring L. This position is indicated in the upper Section. The pull-down tracker M connects the rocking lever with the action from the manual keys. The power-bellows F is secured to the bottom of the chamber, in the position shown, with its hinged end flush with the edge of the bottom. On the top-board of the bellows is fixed the lever arm N, which passes through the block O. This latter is of the width of the bellows and is firmly fixed to its top-board. The leather diaphragm B is glued to the edges of the chamber, the hinged edges of the bellows, and the block O, being

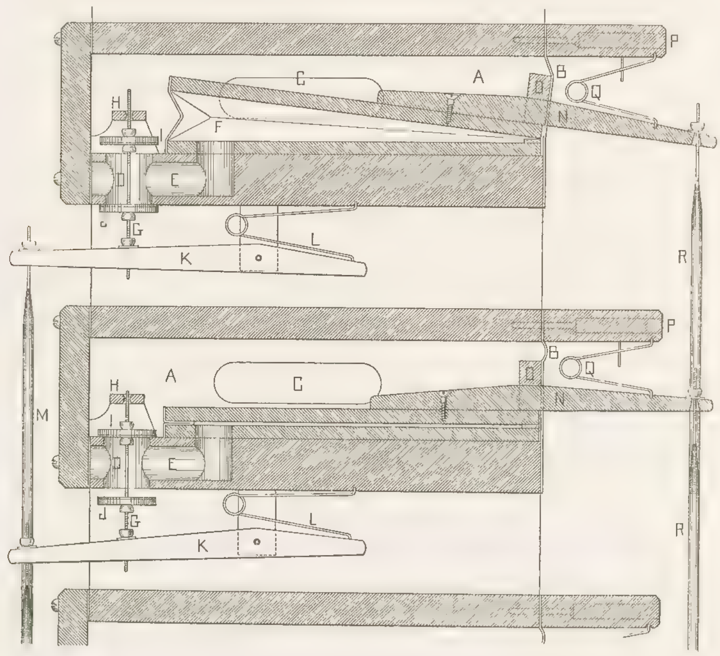


Fig. CLXXXIII.

neatly perforated to allow the arm N to pass through. This diaphragm closes the front of the entire chamber while it does not prevent the movement of the bellows. It is continued throughout the length of the chamber. The extension P is screwed to the chamber to carry the spring Q, which bearing on the projecting arm N aids the return of the wind-chest action which is attached to the tracker R.

The action of the pneumatic lever is as follows: In the upper Section given in Fig. CLXXXIII. the appliance is delineated in its state of rest. The chamber A is filled with compressed air; and as this air also fills the power-bellows F, through the ducts D and E, it remains in its inflated condition under the influence

of the exterior spring Q and the downward pull of the tracker R. The disc-valve J being tightly closed against its seat no compressed air is allowed to escape. On depressing the manual key, the rocking lever K is pulled down by the tracker M, and the disc-valves immediately change position under the pressure of the inclosed air; the valve I falling on its seat and cutting off the compressed air from the interior of the power-bellows; and the valve J falling away from its seat and opening a communication between the interior of the bellows and the external atmosphere. The power-bellows instantly collapses under the pressure of the compressed air in the chamber A, and draws upward the tracker R by its projecting arm N. The flexible diaphragm B allows the small movement at the hinge of the bellows. The relative positions of all the above-mentioned parts, while the manual key is held down, are shown in the lower Section. On releasing the key, the appliance instantly returns to the state indicated in the upper Section. In this pneumatic lever the key action has only to overcome the pressure of the spring L, which is of sufficient strength to keep the valve J closed against the downward pressure of the compressed air, and to lift the tracker M.

The exhaust pneumatic lever invented and patented by Mr. Ira Bassett is certainly unsurpassed by any other appliance of the kind; and in this opinion we are supported by the testimony of several unbiased experts.* The following claims, on points of superiority over all other pneumatic levers, are properly advanced by the inventor: "1st. In efficiency, working as it does upon the exhaust principle, it gives the greatest power at the point most needed to overcome the wind-pressure upon the chest pallet, *i. e.*, at the first start of the valve. 2nd. In promptness, responding instantaneously to the most rapid touch, or in the fullest staccato chords with absolute perfection. 3rd. In quietness, its air cushion rendering it practically noiseless for all time. 4th. In compactness, it requires but one-third the height of the old inflation, therefore can be placed in the most convenient position where it would be impossible to put any other. 5th. Each pneumatic motor, or bellows, is complete in itself, containing all of its own operating and adjusting mechanism, and may be easily removed from its air-chest should it ever

* Mr. W. F. Crosby, the General Manager of the Roosevelt organ factory, while it was in existence, in a letter addressed to Mr. Ira Bassett, dated New York, September 21st, 1888, says: "It gives me great pleasure to speak in commendation of your new Pneumatic Motor for organ action, which you kindly showed to me in operation in Chicago a few days ago. Were it not that the Roosevelt Patent Wind-chest relieves us of the necessity of using slide wind-chests, with their heavy touch as they increase in size, and therefore from the necessity of introducing pneumatic power to render the touch light, we would undoubtedly patronize your new invention, as it certainly is the quietest in operation and the most compact of all the motors that have yet come to my notice. In promptness it is not behind, and I believe excels all others, and in efficiency it secures the very best results possible from a given size of bellows, since it works upon the exhaust principle, where the greatest strength is at the beginning of its motion, viz.: just where it is needed to overcome the suction of the wind-chest pallet. I consider it a logical piece of construction throughout, and that you have in it greatly simplified former devices. Should we find ourselves in a position requiring key action pneumatics we shall call upon you for a set, with the most complete confidence that we shall get the best thing known for the purpose."

Mr. A. B. Felgemaker, organ builder, of Erie, Pa., under the date of Dec. 6th, 1888, writes: "Having carefully and critically examined and tested your patent exhaust Pneumatic, it is with pleasure that I can say that it has a light and agreeable touch, and does its work so perfectly, instantaneous, and without noise, as to leave nothing further to be desired. This with its exceeding compactness and the correct principle upon which it is constructed, render it the best pneumatic that has ever come to my knowledge, if not the best ever constructed."

need repair. 6th. The collapse, or motion of the bellows, is adjustable. 7th. The seat of the inflation-valve adjusts itself to any depth of touch, thus preventing any strain upon the action. 8th. The direct inlet and outlet of the compressed air to and from the bellows. The simplicity and correct principle of the construction with the above-named points, constitute a perfect pneumatic."

In the accompanying illustration, Fig. CLXXXIV., are given Longitudinal Sections of two Bassett pneumatic motors or levers, the lower one of which shows the lever when at rest, and the upper one when it has completed its motion, and

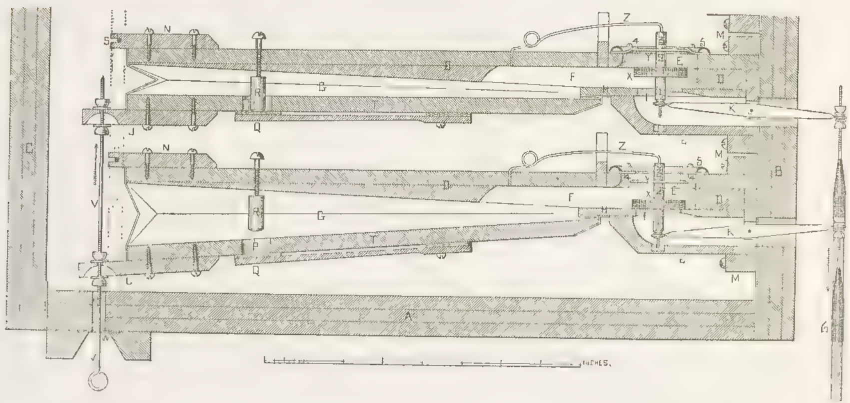


FIG. CLXXXIV.

the manual key is held down. The levers occupy the correct relative positions in the lower part of the compressed-air chamber in which all the levers are placed. In the drawing the bottom, front, and back of this chamber are indicated at A, B, and C. The levers are firmly attached to the front wall of the chamber by screws, leather being glued all over its inner face to receive them. The chamber, containing five tiers of levers, measures internally 18 inches in width, 16 inches in height, and is of sufficient length to embrace the manual clavier, whatever its compass may be. For the ordinary compass of CC to g^3=56 notes an internal length of 35 inches is required. The pneumatic lever is very simple in construction. Its main portion D is formed of bay-wood, 16 inches long, 2½ inches wide, and ⅞ inch thick, the lower part of which is sloped on the under side, as shown, to give proper action to the bellows below. A circular hole, 1⅞ inches in diameter, is bored through the straight, thick end, at E, for the reception of the supply- and exhaust-valves; and from this hole a groove is formed at F, extending some distance into the bellows G. The thin layer of wood H is glued to the straight portion of D, and has a circular valve hole, 1 inch in diameter, bored through it at I, and sloped toward one side, as indicated. Below this is glued the block J, channeled out, in the manner shown, for the passage of the exhaust, and for the reception of the small rocking lever K, which is pivoted at L. All the portions above mentioned,

which form the chief part of the motor, are securely fixed to the front wall B of the chamber by screws driven through the flanges M M ; while the free end of the piece D is supported against any possible vibration by the small arm N, through which the dag S passes into the (dotted) bearing bar O. The bottom-board of the bellows, 12 inches long and 2½ inches wide, has a hole ⅝ inch in diameter bored through it at P. This is for the check-valve Q, which is simply a spring-bar of wood carrying a piece of felt which covers the hole P. The valve coming in contact with the adjustable stop R, as the bellows collapses, is arrested and checks the upward movement of the bottom-board T. The bottom-board, which is hinged to the piece H, is connected with the top-board D by thin and flexible leather, forming a power-bellows of the usual shape. To the free end of the bottom-board is attached the projecting arm U, with which the wind-chest action is connected by the wire V, passing air-tight through the brass plate W. The disc-valves which control the action of the power-bellows are shown at X and Y, and are held in position by three cylindrical pieces of wood, 1, 2, 3, screwed upon a strong tapped-wire, the exposed end of which passes through the bushed eye of the metal rocking lever K. The top of the upper piece 3 is cupped to receive the end of the spring Z, which holds the entire stem in a vertical position, as shown. The lower disc-valve X is formed of millboard, felt, and pallet-leather, while the upper one Y is formed of millboard or celluloid only. The latter, when raised by the key action, beds against the under side of the flexible leather ring 4, which is firmly held in a stretched condition by the metal hoop 5. The disc-valves are moved by the key action which is attached to the outer end of the small metal rocking lever by the pull-down tracker 6.

When the appliance is at rest, as indicated in the lower Section, Fig. CLXXXIV., the compressed air both surrounds and fills the power-bellows, exerting no influence on any part thereof. When the manual key is depressed the valve X is raised from its seat, and the valve Y is pressed upward against its flexible seat 4, as shown in the upper Section. This movement shuts off the compressed air from the interior of the bellows, and allows that already there to escape into the atmosphere through the hole I and the channel in the block J, and the corresponding hole in the wall of the compressed-air chamber B. The compressed air in the chamber instantly forces the leather sides of the bellows inward, and its bottom-board upward until the check-valve Q comes in contact with the stop R. At this point all further motion ceases, the bellows remaining in the state indicated in the upper Section so long as the key is held down. The upward movement of the bottom-board T is regulated by the screw which carries the stop R. The action of the appliance is practically noiseless, the only appreciable sound being caused by the puff of compressed air issuing from the hole in the wall B ; and this is almost entirely removed by enlarging the hole inward and laterally to correspond with the width of the channel in the block J. On the release of the manual key the disc-valves return to the positions shown in the lower Section, the compressed air is again admitted to the interior of the power-bellows, and the bottom-board of the bellows is drawn downward by the pull of the wind-chest action connected with the wire V. The action of this pneumatic lever is instantaneous and in every way

satisfactory. An actual working lever presented to us by Mr. Bassett has enabled us to prepare accurate drawings of the same, and to bear testimony as to its superiority over every other pneumatic lever known to us.

In his patent,* Mr. Bassett shows the manner in which his exhaust pneumatic lever can be converted into a pressure or inflation pneumatic. It is reversed, the bottom-board in the former becoming the top-board of the power-bellows in the latter; and it is attached to the exterior of a compressed-air chamber, the channel through which the power-bellows is exhausted in the one form becoming the supply channel in the inflation pneumatic. The disc-valves are moved so as to close their respective orifices on the outside; and the check-valve is fastened inside the bellows, and comes in contact, as the bellows is inflated, with its adjustable stop placed above it on the outside.

The advantages of the exhaust over the older pressure or inflation pneumatic lever are important: the former is much more prompt and certain in its action, more silent, and much more durable, than the pressure pneumatic; and when entirely inclosed within a chamber or box, as in the case of the Bassett exhaust action, its durability is greatly prolonged, while its valves and other acting parts are preserved in an efficient state by being well protected from dust and dirt. In the Bassett appliance the smallest practicable dimensions have been arrived at, and, accordingly, its introduction can be rarely attended with difficulty.

The pneumatic lever will not now be often used, being necessary only in instruments built on the older lines, in which slider wind-chests and ordinary long tracker actions are introduced. It is, however, an extremely interesting and ingenious appliance, intimately connected with the development of organ-building in the nineteenth century.

* "Pneumatic Action for Organs." United States Patent, No. 387,846, dated August 14, 1888.

CHAPTER XXVII.

THE VENTIL WIND-CHEST.

— MECHANICAL —

THE term Ventil Wind-chest is commonly used to designate the form of wind-chest in which each stop planted thereon is supplied with wind from a separate chamber, extending longitudinally the entire length of the chest, and into which the compressed air is admitted by means of a special *ventil* commanded by the draw-stop action; hence the name, to distinguish this form of chest from the slider and pallet wind-chest described in Chapter XXIV. In the ventil wind-chest every pipe planted thereon is furnished with its own wind-valve: and all the valves of each stop are contained in the longitudinal chamber belonging to the stop.

In certain variants of the ventil wind-chest the wind is supplied from a general or so-called universal air chamber, while each pipe or note of every stop planted thereon is commanded by a separate and individual pallet, valve, or ventil, actuated by the key action. In these wind-chests an internal draw-stop action has to be provided which considerably complicates the general construction.

The advantages attending a properly constructed ventil wind-chest having separate air chambers may be described in a few words. First, the ventils, being small, leather-covered valves or pallets, are very easily opened and closed by means of a direct tracker or some simple pneumatic draw-stop action, which, in turn, admits of an equally simple and an easily applied combination action. The stop ventils, being so certain in their operation, have a decided advantage over the long sliders of the older form of wind-chest, which require a comparatively powerful draw-stop action to move them; and which, unless most skilfully made and of the most suitable material, are very liable to give trouble by sticking when tightly fitted, or by allowing the wind to run or escape when they work too loosely. Secondly, as each stop has its own special and distinct air chamber from which it is supplied, there is no chance of the stops robbing each other of their proper wind

supply, even when all the stops on the chest are speaking at the same time. To secure a perfect result, it is only necessary for the air chambers to be sufficiently wide and deep to prevent any practical diminution of pressure through the friction of the compressed air against their walls as it rushes from the ventils to supply the more distant pipes. It is also necessary that the ventil openings should be of sufficient size to admit a much greater supply of compressed air than could, under any circumstances, be required by the pipe-work. Thirdly, as every pipe on the chest has its own special valve, commensurate in size with the pipe to which it admits the compressed air, and as the valve is located in close proximity to the foot of the pipe, the speech of the latter is rendered prompt and invariably of the same strength or volume.

There have been so many different forms of the mechanical ventil wind-chest introduced since its inception that it is not possible, in the space at our disposal, to describe and illustrate even all the more noteworthy ones. It is not even desirable that so comprehensive a survey should be essayed, because there are numerous forms which merely present a distinction without a difference. Indeed, in nearly all the mechanical ventil chests the principles of construction are the same, slight modifications having been made, from time to time, by different builders with the view of giving them some little prominence in their art, and furnishing them with a peg whereon to hang claims for originality, inventive skill, and public recognition. In this direction history is repeating itself in the organ-building world to-day, making the labors of the would-be historian difficult to a degree beyond the ordinary student's comprehension.

The invention of the ventil wind-chest is due to German ingenuity, but to whom its inception is due, or at what date it first assumed a definite form, we are not in the position to state. It would appear, however, from the statement issued by Messrs. E. F. Walcker & Co., of Ludwigsburg, that the first practical form of the ventil wind-chest, called by them the "Walcker'sche Kegellade" (Walcker cone-chest), was invented by the founder of the firm. They say: "The Walcker cone-chest, invented in 1842 by the founder of our firm, our late father E. F. Walcker (died 1872), can justly be characterized as one of the most epoch-making innovations of this [nineteenth] century in the field of organ-building. Throughout its existence of now half a century, it has enjoyed almost universal recognition and application far beyond the limits of Germany, and up to the present [1893] is still, on account of its durability and serviceableness, the most widely adopted of all mechanical wind-chests."* It must be understood that the closing remarks are

* "Multitudinous wranglings and litigations have been indulged in by those claiming the patent on the invention of this form of wind-chest. Mr. Walcker, Senior, of Ludwigsburg, has in all seriousness asserted his claim as the inventor; and it is not to be doubted that he invented the ventil-chest now in vogue [1888]. But it is equally certain that it was used in South Germany and Hungary before the date of his invention. Previous to the middle of the nineteenth century there were, according to the accounts of old organ-builders, wind-chests extant which were constructed on the ventil system. In a copy of the book entitled 'Kunstgewerbe und Handwerksgeschichte der Reichsstadt Augsburg, von Paul Stetten [History of the Art Industry and Handicrafts of the Imperial City of Augsburg, by Paul Stetten], published in 1779, to be found in the Royal Library of Berlin, one reads, on page 161, the following remarks on an Organ of that time: 'It contains a remarkable bass-chest in which the wind is said to be fed to each pipe separately, and is regulated by a small inverted cone.' Likewise, the 'Kunstzeitung' [Art Journal] of the Imperial Academy at Augsburg, for the

only applicable to German organ-building. The construction of this early form of ventil wind-chest will be readily understood from the accompanying illustration, Fig. CLXXXV., which is a Transverse Section of portion of the chest showing the arrangement for three stops. The construction is extremely simple, as all the wind-ducts which supply the pipes are formed by boring in different directions in

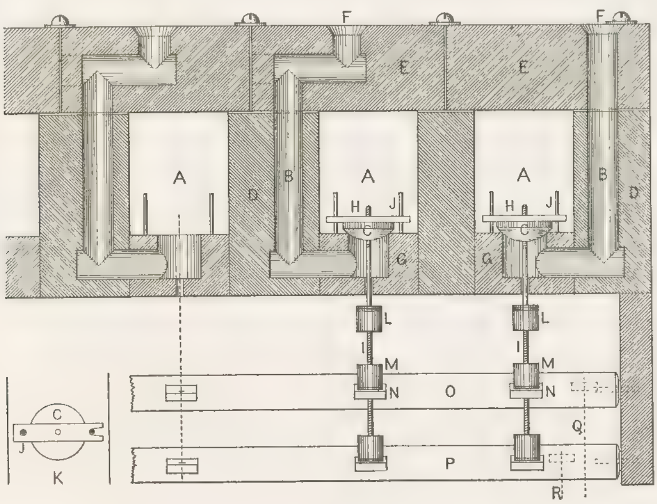


FIG. CLXXXV.

stout pieces of wood, which extend the entire length of the chest, and form the bars, valve seats, and upper-boards. A A A are the longitudinal chambers, filled with compressed air from the draw-stop ventil-box, situated in the center or at one end of the chest. Each stop has its own chamber, and is "drawn" by simply opening its special ventil and allowing the compressed air to enter the chamber. The wind-ducts B B convey the compressed air from the valves C C, through the borings in the bars D D, and the upper-boards E E, to the feet of the pipes at F F. To reduce to a minimum the liability of the valve seats to alter their circular form through any contraction or expansion of the wood, the bottom pieces G G are

year 1870, contains, on page 43, the following remarks concerning the Organ in the Barfüsserkirche, in which is expressly mentioned the name of an inventor of a ventil wind-chest. 'It has been long ago observed that the numerous bass stops rob the wind from each other in spite of double pallets; consequently the resulting tone is feeble and false. This has induced Mr. Stein to adopt a different bass-chest; namely, that invented by Mr. Hausdörfer, sometime organ builder at Tübingen. This invention, which has been improved upon in various ways by Mr. Stein, and so adapted for general use, deserves recognition for its highly practical character, especially as it has nothing in common with the slider wind-chest as hitherto used, or with the now antiquated Springlade [spring-chest]. It is altogether an excellent idea to give to each pipe its special wind supply.' Here, again, we unquestionably find a species of ventil wind-chest alluded to."—"Die Theorie und Praxis des Orgelbaues" by Töpfer-Allihn, 1888.

properly made of the best close-grained and perfectly seasoned mahogany. The valve seats are bored with the greatest care so as to leave perfectly clean edges for the valves to rest against. A small hole is bored through the bottom of each valve seat for the passage of the valve-stem I, which is a stout, hard brass wire, tapped at both ends. The valves C C, preferably made of some heavy material not liable to warp, are turned in the form shown, and have their curved surfaces covered with soft leather so as to secure a noiseless and perfect contact with their seats. They are held in position by the guide-bars H H, which work on the brass guide-pins J J. The top view of a valve is given at K. The upper ends of the stems I I are screwed through the valves, while on their lower portions are screwed the studs L L and M M, which are of hardwood, turned, and faced with layers of felt. The upper studs L L bed against the bottom of the chest when the valves are raised, while the lower studs M M lightly touch the arms N N of the roller O when the valves are closed, as indicated. When the roller O is turned by the key action, the arms N N move upward, raising the studs and their attached valve-stems I I until the upper studs L L rest against the surface of the chest. The valves C C having been raised by this movement, the compressed air in the chambers A A rushes under them and through the ducts B B into the pipes at F F. While in this form of ventil chest all the valves belonging to each note of the same name in all the stops planted on it, are moved simultaneously by the corresponding roller, only those stops speak whose chambers are filled with compressed air from the ventil-box. When the roller arms descend on the release of the key action, the valves fall of their own weight, and bed securely under the pressure of the air in the chambers. The rollers extend transversely the entire width of the wind-chest so as to engage the valves of every stop, and they are arranged alternately in two tiers, as shown at O and P. This arrangement is necessary, because in the treble portion of the chest the valves lie so closely to each other that their stems could not be engaged by the arms of rollers placed on one plane. Their stems are, accordingly, actuated by the upper and lower rollers alternately, those which descend to the lower rollers passing through perforations in the arms of the upper rollers. The rollers are connected with the key action by pull-down trackers, attached to arms inserted near one end of the rollers in the direction opposite that of the valve arms. The positions of the arms and pull-downs are indicated by the dotted lines at Q and R.

Instead of the roller action, as above described, and originally used by Walcker, a square action has sometimes been applied to the Walcker chest. This action, in one of its forms, is illustrated in Fig. CLXXXVI. The construction of the chest (the lower portion only of which is shown) is identical with that given in Fig. CLXXXV. The valves A A are of the disc or mushroom form, and have flat seats. They are made of thick discs of hard millboard, specially prepared, or some other suitable material, the under surface of which is covered with soft pallet-leather, securely glued on. Guide-bars are fixed across their upper surface, and work on guide-pins in the manner shown at K in Fig. CLXXXV. As it is necessary that valves of this flat form shall at all times bed perfectly around their edges, they require, instead of being fixed rigidly on their stems, to be given

sufficient play thereon. This is conveniently done by firmly gluing them in the center to the small cones of hardwood B B, also faced with leather. These cones are screwed on the ends of the brass stems C C. As the action is altogether a pushing one, and no force is exercised in closing the valves, which fall of their own weight, the attachment of the leather of the cones to that of the valves is sufficiently secure, while it allows the valves to rock to the very small extent that may be necessary. On the lower part of the stems the felt-faced studs D D and E E are screwed, fulfilling the same offices as those previously described. The bottom studs E E lightly touch the twisted ends of the brass squares F F. The lower arms of the squares are pinned to the links G G, and these, in turn, are

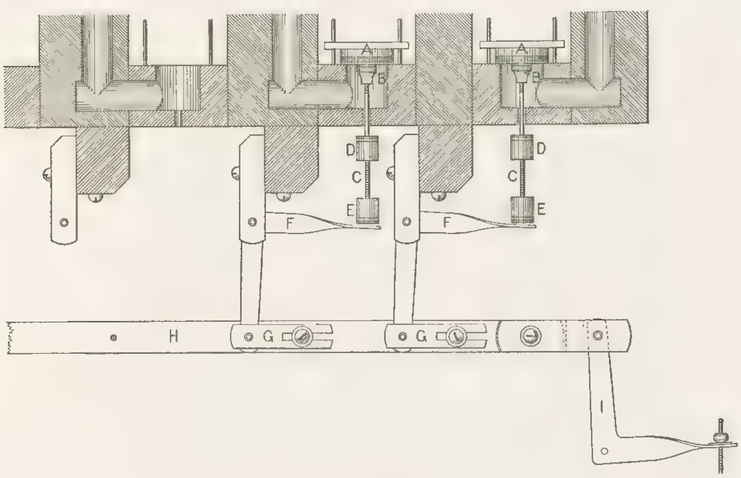


Fig. CLXXXVI.

screwed to the horizontal, transverse rod H. When this rod is drawn by the movement of the square I and the pull-down tracker, all the valves on the line are pushed up, and the stops speak whose chambers are charged with compressed air.

Now, while both the mechanical arrangements we have described are perfectly efficient so far as furnishing a prompt and liberal supply of wind to the pipe-work is concerned, they have, when simply connected by a direct tracker action with the clavier, the great disadvantage of creating a key touch which varies in its weight or resistance with every stop that is drawn or put in. The minimum resistance to the finger is when the smallest stop is alone speaking; and the maximum resistance is, of course, when all the stops are drawn, and every valve is subject to the downward pressure of the wind in the chambers. Mechanical actions of this class, therefore, call imperatively for an intermediate auxiliary, the action of which remains constant at all times so far as the key touch is concerned. Such an auxiliary power is furnished by the pneumatic lever in its perfected form.

In the two illustrations already given two forms of valves are represented, but neither of them is the form of the valve which gave the name "Kegellade" to the ventil chest. The original valve seems to have been in the shape of a true cone, inverted, as clearly indicated in the diagrams given in certain German treatises on organ-building. The most perfect form of the cone-valve is probably that used by the late distinguished builder Mr. Haas, under whose guidance we had the privilege of studying the construction of his noted Organ at Lucerne. This valve is illustrated in Diagrams 1 and 2, Fig. CLXXXVII. It is formed of two parts,

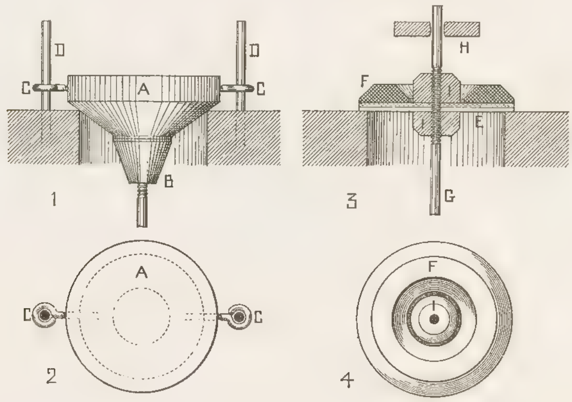


FIG. CLXXXVII.

A and B, which are attached by being securely glued to an intermediate disc of thick leather, which allows the valve proper A to rock sufficiently to bed itself under all conditions. The valve is held in a central position by the two brass eyes C C, which slide on the guide-pins D D. The valve-stem E is screwed into the shank B. The most satisfactory form of the flat disc-valve is that invented by Mr. Koulen, of Strasbourg. A Section and Top View of this valve are given in Diagrams 3 and 4. It is constructed of a disc of pallet-leather E, formed of two plies glued together, upon which is cemented a cast ring of pipe metal F. The stem G passes through the center of the disc, and the valve is supported thereon by two stout leather nuts I I. This clever arrangement provides for every demand that can be made on the valve. The upper end of the stem is held in position by the guide-bar of hardwood H. Certain other forms of valves have been introduced by German builders, including the hemispherical, which has been advocated on the ground that whether it is perfectly true on its stem or not, or whether its stem is vertical or not, the valve will invariably present a true circle to the edge of its seat. This is true so far as the valve is concerned; but the real difficulty lies in its seat or opening into which the valve drops; for so long as this opening is simply bored in wood, liable to contraction and expansion under different conditions of the atmos-

phere, it will be found impossible to secure a perfectly circular seat at all times. If the hemispherical valve is used, either its surface or the edges of its seat must be covered with soft leather, so that the valve may bed securely and noiselessly. Of the other forms of valves it is unnecessary to speak.

An examination of German works on organ-building shows conclusively that a great deal of ingenuity has been expended in the construction of ventil wind-chests. While some few of these chests are desirably simple in their construction and action, others are characterized by excessive complexity. We shall illustrate some of the simpler forms which represent different modes of operation, and, to some extent, different principles of construction.

In Fig. CLXXXVIII. is given a Transverse Section of three stop-compartments or chambers of a ventil wind-chest, showing the mode of construction in which the several valves belonging to each note in the compass of the chest are carried on a single horizontal wire, which passes transversely across the chest,

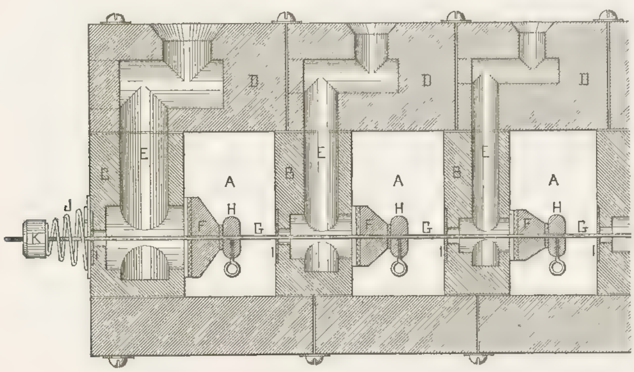


Fig. CLXXXVIII.

through all the stop-chambers, the partitions, and the front and back cheeks of the same. At A A A are the longitudinal stop-chambers into which the compressed air is admitted by the ventils connected with the draw-stop action. B B are the longitudinal bars or partitions, C the back cheek of the chest, and D D D are the upper-boards, through which the channels E E E, that convey the wind from the stop-chambers to the pipes, are bored in the manner indicated. The valves F F F are of hardwood, carefully turned, and faced with leather and felt. They are strung tightly on the horizontal wire G, and held in position, when accurately adjusted, by means of the binding nuts H H H. The wire G is supported by the brass plates I I I, through holes in which it passes easily and practically air-tight. The valves are held tightly against their seats by means of the spiral spring J, the pressure of which is regulated by the large nut K. The bottom pieces can be readily removed at any time for the adjustment of the valves that may have slipped :

they are screwed against the leathered edges of the partitions and cheeks. The upper-boards D D D are also movable and bed on leather, as indicated. Several practical difficulties were found to attend the construction of this form of wind-chest, chief among which was the difficulty of adjusting all the valves on each wire to bed exactly alike and squarely on their seats. To overcome this difficulty, several forms of valves were devised which would rock sufficiently on the carrying wires to bed properly at all times, and the valves were, in some instances, fitted with special spiral springs, placed between them and their binding nuts, which secured their proper bedding at all times. It was, of course, necessary to have a second binding nut in front of each valve, to hold it in position, and to limit the action of its spiral spring. Notwithstanding all these inventions and precautions, and the fact that the general principle of construction was adopted by several distinguished German organ builders, this form of ventil wind-chest did not meet with general approval.

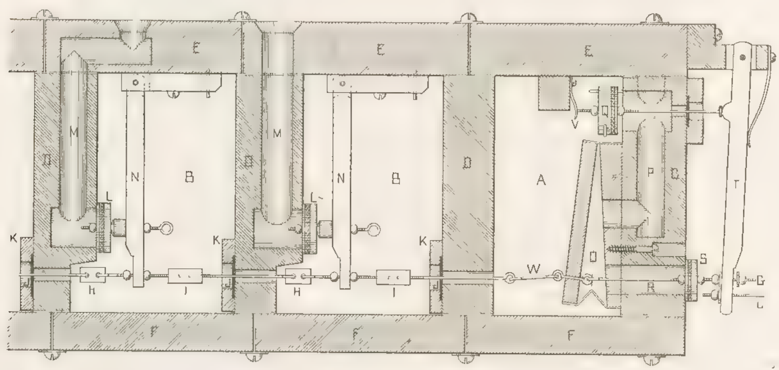


Fig. CLXXXIX.

A much more satisfactory treatment, based on the same general principle, in which the chief objections to the previously described chest are overcome, is shown in Fig. CLXXXIX., which is a Transverse Section of the front portion of a ventil wind-chest. A is a longitudinal chamber which is always charged with compressed air while the Organ is being used, and B B are stop-chambers into which the compressed air from the bellows is admitted by the ventils connected with the draw-stop action. The chest is formed in the same manner as the preceding example, the front cheek being shown at C, the bars or partitions at D D D, the upper-boards at E E E, and the bottom pieces at F F F. Instead of the single transverse wire, as shown in Fig. CLXXXVIII., we have here linked wires, which allow of a certain degree of movement in the several parts without causing undesirable binding or friction. These linked wires G extend from the key action before the front cheek, through the chest, and are attached to a spring outside the back cheek

which is sufficiently strong to recover the key action and close all the valves in the stop-chambers. The wires, which are of phosphor-bronze, are linked at H H by pieces of stiff leather, and at I I by nuts of beech or boxwood. The wires pass air-tight through the brass plates J J J, which are held in position by the perforated strips of wood K K K. L L are disc-valves covering the entrances to the wind-ducts M M. The valves are formed of prepared millboard faced with felt and soft pallet-leather; and are firmly held in position by tapped-wires and leather buttons to the pendant levers N N. The lower ends of these levers are forked on the horizontal wires between leather buttons, which hold them in proper position and communicate motion to them. It will be observed that the buttons on the left side of the levers are not screwed close to the levers: this is to give the horizontal wire a very small draw before the levers and their valves are moved. We now come to the front portion of the chest. In the compressed-air chamber A is fixed the small bellows or pneumatic lever O, the moving board of which is linked externally and internally to the wire G, as indicated. The upper channel P admits the compressed air from the chamber into the interior of the bellows when the disc-valve Q is open in the manner shown; while the air in the bellows is not allowed to escape through the duct R as long as the external disc-valve S is closed. Under these conditions, the bellows remains expanded and at rest, as indicated. The valve S is held in position by the pendant lever T, through which the wire G passes. Two leather buttons and cloth washers convey the motion of this lever to the wire. Immediately below the wire G another tapped-wire U passes through the lever and connects it with the key action. The operation of the appliance is as follows: When the manual key is depressed, the tracker wire U is drawn in an outward direction, the lever T is moved slightly until it comes in contact with the outer button on the wire G, at the same instant allowing the valve Q to close by the pressure of the small spring V. Immediately the air is cut off from the channel P, the outer surface of the bellows O comes under the action of the compressed air in the chamber A, and as the valve S has in the meantime been drawn from its seat by the lever T, the bellows collapses, assisting to a considerable extent the key action and lightening the touch. It is almost unnecessary to remark that the bellows must be made so small that the pressure of the wind upon it will be properly subordinate to the strain exercised by the recovering springs. When the independent pneumatic lever is applied to the key action, the chamber A and all its attendant mechanism becomes unnecessary, and the key action can be connected with the horizontal wire at W. As all the moving parts can be readily adjusted, and as the valves L L rock sufficiently on their wires to bed properly at all times, this form of ventil chest may be considered the most satisfactory of its class.

The ventil wind-chest used by the distinguished organ builders Messrs. Abbott and Smith, of Leeds, closely resembles that just described. Instead, however, of all the pallets belonging to each note being so linked together as to be closed by the action of a single recovering spring, each pallet is furnished with a light pallet-spring. The pallets are actuated by horizontal wires passing through leather purses attached to the bars dividing the compartments or air chambers, and linked together so as to secure perfect freedom in action. Under the command of the

pneumatic lever this wind-chest proves generally satisfactory. It is comparatively simple in construction, and when properly adjusted—an easy matter—it is not liable to derangement.

We have now to direct attention to another form of ventil wind-chest which is stated to have been first introduced by Messrs. Poppe Brothers, organ builders, of Roda. In this chest the somewhat objectionable mode of carrying all the valves belonging to each note on a single wire, or on linked, horizontal transverse wires is abandoned, and each valve is carried on an independent stem, and is actuated by a special lever, all admitting of a separate and easy adjustment from outside the stop-chambers. The advantages of such an arrangement are manifold and obvious. A Transverse Section of two stop-chambers of this wind-chest is given in Fig. CXC. The stop-chambers A A are formed by the bars B B and C C, the upper-

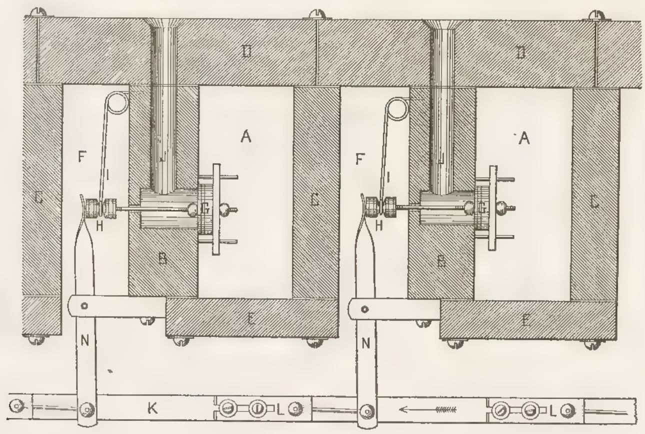


Fig. CXC.

boards D D, and the bottom pieces E E. The bars are held in position by being mortised into the thick end cheeks of the chest, and, accordingly, allow the upper-boards and the bottom pieces to be removed when necessary. The spaces F F between the bars are open to the external air, and form a special feature of this class of wind-chest. The disc-valves G G are secured on their hard brass stems by double leather buttons, while they are allowed sufficient freedom to rock slightly; they are supported by small guide-bars and pins inside the stop-chambers, and by their stems passing through small holes in the bars B B, as shown. Two turned nuts of beech or boxwood, faced with soft leather, are screwed on the ends of the valve-stems at H H, having between them the eyed ends of the recovering springs I I. These springs are only sufficiently strong to promptly close the valves when the key action is released, the condensed air in the chambers aiding the operation and ultimately holding the valves tightly over the openings in the

wind-ducts J J. The key action is linked to the horizontal, transverse rod of wood K, to the side of which are screwed the adjusting pieces L L, linked by short wires to the brass levers N N. When the rod K is drawn by the key action in the direction indicated by the arrow, the upper, twisted ends of the levers N N press on the nuts H H and open the valves G G, and admit the compressed air to the pipes standing over the ducts J J.

A ventil wind-chest similar to the above in the general principle of construction, but somewhat different in detail, was introduced by the celebrated German organ builder Mr. F. Ladegast, and used by him for the Pedal Organ stops. When a simple tracker action is employed, this form of chest is in every way suitable for the pedal department of an Organ of moderate dimensions. It secures promptness

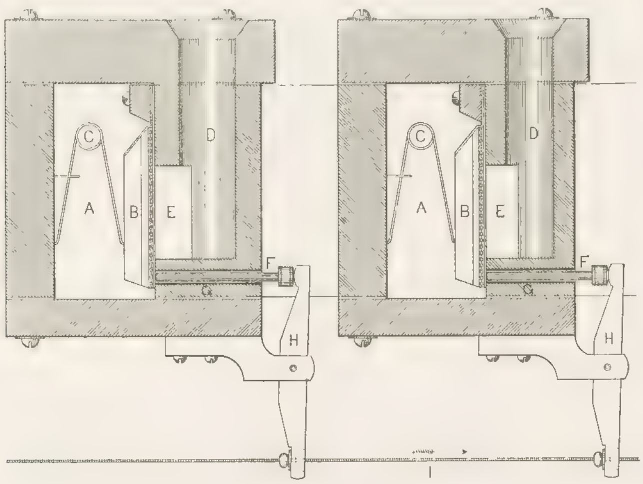


Fig. CXCI.

of speech and a uniform supply of wind at all times—all-important matters in connection with large pipes. A Transverse Section through two stop-chambers of this wind-chest is given in the accompanying illustration, Fig. CXCI. The stop-chambers A A, which contain the compressed air for the supply of the pipes, are formed precisely in the same manner as those previously illustrated (Fig. CXC.) and described. Here, instead of horizonally-acting disc-valves, we find hanging valves in the shape of oblong pallets, B B, hinged at top, and held against their seats by light pallet-springs, C C. To admit the necessary amount of wind into the pipe-ducts D D, oblong openings, E E, are cut into them, as indicated. Both these openings and the valves that cover them can be elongated to any desirable extent. The valves are pushed open from the outside by the hardwood rods F F, which pass through brass tubes inserted in the thick bars at G G. The

heads of the rods are leathered on both faces, the leathering of their inner faces rendering the action silent, at the same time stopping any escape of the compressed air while the valves are open. The rods F F are actuated by the levers H H, which are connected with the key action by the horizontal wire I. The different stop-chambers of this wind-chest may be placed any distance apart that the pipes planted on them may render necessary.

Another form of ventil wind-chest is shown in Fig. CXCII., which is a Transverse Section through two stop-chambers. Its peculiarity consists in the inclined valve seat, which renders the use of pallet-springs unnecessary, and to a large degree lightens the touch when a direct tracker action is employed. The first introduction of a wind-chest constructed after the fashion of that shown in Fig. CXCII.

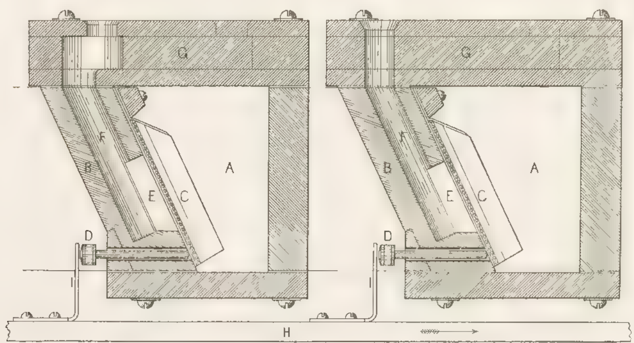


Fig. CXCII.

appears to be due to Mr. Hundeck, organ builder, of Ober-Glogau. His valves were actuated from the exterior of the stop chambers in a manner similar to that indicated. As the great advantage which attended the use of valves or pallets that closed of their own gravity without the aid of springs, was readily recognized, it is not to be wondered at that we find the inclined valve seat introduced in several of the more complicated wind-chests constructed by ingenious German organ builders. This is notably the case in the wind-chests which have a general compressed-air chamber, common to all the stops planted on them.

The construction of the wind-chest now under consideration is extremely simple. A A are the stop-chambers into which the compressed air is admitted by the draw-stop ventils. B B are the bars, fixed obliquely, which furnish the inclined seats for the pendant valves or pallets C C. When the valves are pushed from their seats by the small rods D D, the compressed air in the stop-chambers rushes through the oblong openings E E into the wind-ducts F F, and thence into the pipes planted over them. When the key is depressed by the finger the horizontal rod H is drawn by the key action in the direction indicated by the arrow; and the metal arms I I coming in contact with the leather-covered heads of the rods

D D press them inward, and these, in turn, push the valves from their seats. The horizontal parts of the arms I I are forked so as to allow them to be accurately adjusted on the rod H. When the key is released, the motions are reversed, and the valves fall of their own weight against their inclined seats and become closely held by the pressure of the wind in the stop-chambers. In the absence of springs the key action has merely to overcome the pressure of wind on the closed valves and to lift the very small weight of the valves themselves. The instant a valve is lifted from its seat in a chamber charged with compressed air all resistance beyond the weight of the valve ceases; and in all the chambers in which there is no compressed air there is no resistance beyond that due to the small weight of the valves. With a key action furnished with the pneumatic lever, this form of wind-chest would prove highly satisfactory. Instead of using horizontal rods carrying vertical arms, a lever action, such as is shown in Fig. CXCI., may be adopted.

It appears that this form of ventil wind-chest was introduced into English organ-building by the late Mr. Henry Willis. The form of his stop-chambers differs slightly from that shown in Fig. CXCII., but the principles of construction are identical. We understand this wind-chest was first used by him in the Grand Organ in the Royal Albert Hall, London. We do not, however, remember having seen it when we inspected the Organ, while in course of construction, accompanied by its distinguished builder.

In the preceding descriptions our remarks have been confined to those parts of the wind-chests in which the valves or pallets, which admit wind to the pipes, are located; and we may now close this section of the present Chapter with a few words respecting the ventil-boxes, from which the compressed air is admitted to the several stop-chambers by the ventils commanded by the draw-stop action. The ventil wind-chest, as constructed by German organ builders, is usually in two divisions, on which the pipes are planted tonally. These divisions are securely braced together, and over the junction, and extending some distance on each side of it, is placed the ventil-box, admitting the compressed air to both divisions of the chest simultaneously. The ventil openings have to be of sufficient dimensions to admit wind to their respective stop-chambers greatly in excess of the quantity that can possibly be required in legitimate playing with all couplers drawn. The accompanying illustration, Fig. CXCIII., which is a Longitudinal Section through the central portion of a wind-chest with its ventil-box attached, fully explains the preceding remarks. A B are the two divisions of the wind-chest joined together at C. D is the bottom board of the ventil-box, through which are cut the openings E E for the passage of the compressed air from the chamber F into the stop-chambers A B. The chamber F is partitioned so as to confine the air which enters it through the ventil opening G to the stop-chambers over which it is placed. Accordingly, there is a separate chamber provided in the length of the ventil-box for each stop planted on the chest. H is a chamber which extends the entire length of the ventil-box, and which is connected with the wind-trunk from the receiver of the bellows or the intermediate reservoir. I is the ventil in the form of a large pallet, which is pushed open by the draw-stop action through the agency of the vertical

sticker J. When the ventil is opened the compressed air rushes into the lower chamber F, and thence, through the openings E E into the right and left stop-chambers A and B. The construction of the wind-chest is similar to that shown in Fig. CXC.

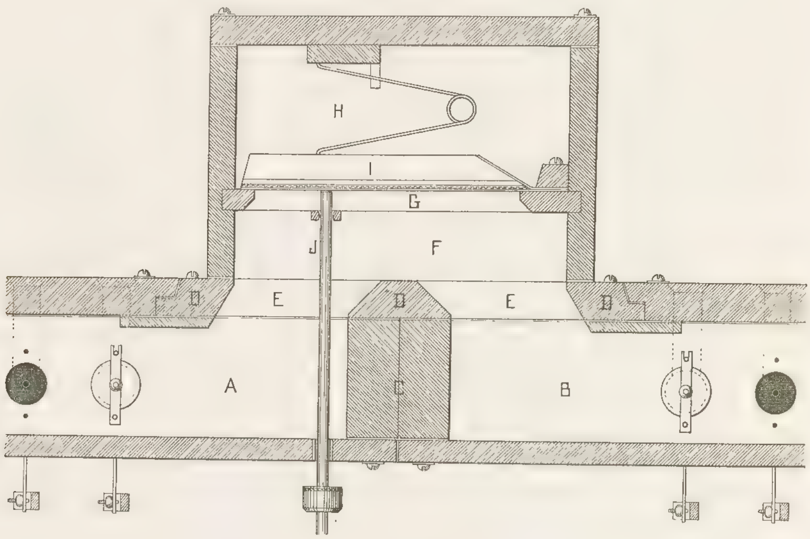


Fig. CXCIII.

The ventil wind-chests which have been considered up to this point, have all separate stop-chambers, each of which is furnished with a special ventil commanded by the draw-stop action. The inventive powers of the German organ builders did not, however, stop at this class of chest; on the contrary, excited by the desire to introduce something specially noteworthy, several of the leading builders contrived chests, which are chiefly characterized by undesirably elaborate forms of construction. Alluding to the exercise of ingenuity in this department of organ construction, almost amounting to a craze on the part of the modern German builders, Max Allihn, writing in 1888, remarks:

"A glance over the history of organ-building during the last ten years impresses one with the inventive fever which seems to have seized the organ-building world. To be in command of the situation it seemed necessary to pose as an inventor: only, curiously enough, the most eminent masters cared the least for this title. The acquisition of patents also was deemed of great moment; and yet we cannot recall an organ builder who could trace his success or wealth to a patent. Nevertheless, thought, money, and time were sacrificed uselessly, much paper was wasted, much wrangling was indulged in, much bitterness was stored up, and all with negative results. . . . Patent claims do not cover an idea in general, but

merely a definite embodiment of an idea. Truly, therefore, organ builders ought to relinquish the notion that fame and fortune are to be gained through the legal monopoly of an invention, when the only point that really tells is an all-round ability in one's vocation. The cause of organ-building in general, and the interests of individual organ builders, would be best served by mutual communication and coöperation in all new subjects open to discussion. By such means organ builders would further their own interests and the good of their art, instead of losing much by isolating themselves, and showing ill-will by disparaging one another."

Previous to entering on the quotation just given, we alluded to certain forms of wind-chest which are chiefly characterized by elaborate construction—a very undesirable thing in organ-building. In these wind-chests, instead of there being several separate stop-chambers, the entire chest forms a single general compressed-air chamber, in which all the pipe-valves of all the stops are placed, and in which both the mechanism for directly controlling the stops, and that for directly operating the pipe-valves, are inclosed. This system of construction was adopted with the view of furnishing at all times an ample supply of wind to the pipe-work; but it is very doubtful if the chests constructed in accordance with it are any better in this direction than those furnished with separate stop-chambers; provided, of course, that the stop-chambers are of sufficient size and that their ventils admit the requisite amount of wind. It is quite certain that the somewhat complicated nature of the draw-stop mechanism introduced in some of the single-chambered or so-called universal wind-chests was attended with serious disadvantages. The inclosed mechanism was always difficult of access for adjustment and repairs; and we should think from a careful study of such mechanism, which combines both the draw-stop and pipe-valve apparatus, that it would often call for adjustment, even when absolute repairs were not necessary.

We illustrate and fully describe only a single representative example of this class of universal wind-chest, referring our readers who are curious on the subject to the drawings of the several modes of construction given in the German work, "Die Theorie und Praxis des Orgelbaues."

Fig. CXCIV. is a Transverse Section of portion of a single-chambered or universal wind-chest, constructed according to the system invented by the German organ builder Randebrock, and in which the combined mechanism is not of a very complicated character. A is the universal chamber, supplied with compressed air from the wind-trunk of the division. In this chamber are placed all the pipe-valves belonging to the complete series of stops in the division of the Organ: three of these valves are indicated at B, C, and D, commanding the pipe ducts, E, F, and G. These valves and ducts belong to three different stops. The inclined blocks H H H are repeated throughout the length of the chamber, one for every pipe planted on the chest. Continuous bars may be substituted for the series of blocks. The upper-boards I I I are so made that any one can be removed to give access to the pipe-valves. The bottom J J is also made in several pieces, longitudinally, which can be readily removed, carrying with them the draw-stop mechanism, and giving access to the jacks of the internal key action. In describing the internal key action we confine our remarks to that affecting a single note. The valves

B C D are pushed open by the brass jacks K L M, which are pivoted in slots in the horizontal rod N. The valve D is shown pushed from its seat by the jack M, the latter being held in position by the draw-stop mechanism below it. The jack L is also held in position to open the valve C when the rod N is moved in the direction indicated by the arrow. The jack K is shown in its inoperative position, or when the stop is not drawn. In this case the rod N can be moved without the jack coming in effective contact with the valve B. The rod N is drawn forward by the brass square O, the lower arm of which presses against the leather covered stud P, while its upper arm is drawn downward by the pull-down wire Q, connected with the external key action. The rod N is drawn back, when the manual key is released, by a spring acting on its other end. The spring has been applied

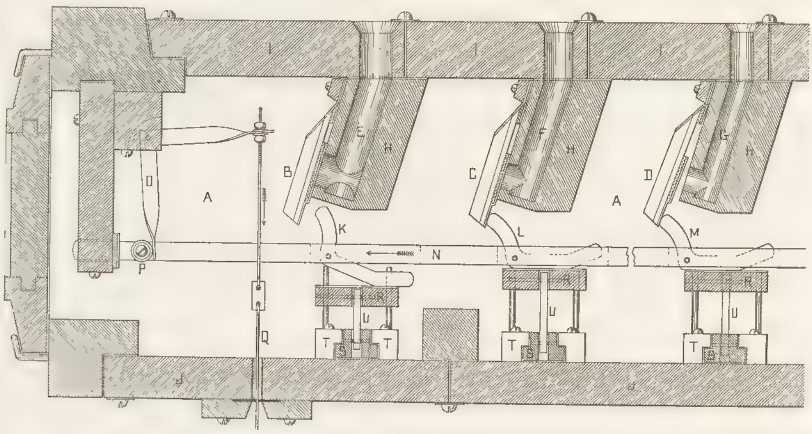


Fig. CXCIV.

to the rod adjoining the actuating square; but as it is always better to pull than to push a long and slender rod of wood, the spring is in its proper position at the opposite end. The draw-stop mechanism located within the chest is extremely simple. It is constructed on the principle of the old-fashioned parallel ruler. It consists of a flat strip of hardwood R, faced with firm, smooth leather, well black-leaded so that the lower edges of the brass jacks may glide on it easily; and a rod S, which slides between the guide blocks T T, screwed to the bottom piece J. The strip R, which rises and falls in a vertical direction on brass guide pins, and the rod S, which moves horizontally in the longitudinal direction of the chest, are connected together by several brass links pivoted in slots, as indicated at U. When the draw-stop rod S is pushed in by the external action, the links become inclined and lower the strip R, as shown under the jack K; and when the rod S is pulled forward, the links assume a vertical position and raise the strip R, as shown under the jacks L and M. The rod S is moved by means of a strong wire, which passes

through one of the end cheeks of the wind-chest, and is attached to the external draw-stop action, probably in the form of a pneumatic lever.

The wind-chest just described and illustrated practically embodies the general principles of construction which obtain in all single-chambered, or so-called universal, wind-chests. Several different mechanical devices have been adopted by distinguished German organ builders; but while their modes of action vary somewhat, the results arrived at—of doubtful value—remain the same. One thing is certain, that no additional steadiness of wind is secured beyond that attained in properly-constructed compartment chests. And another thing is certain, however capacious the air chamber may be, it furnishes no greater supply of compressed air to the pipe-work than that given by the feeders and the blowing apparatus. Universal wind-chests when properly constructed are both expensive and cumbersome, and until tonal results are obtained that are impossible under more economical methods of construction,—and such results have certainly not been reached up to this year of Grace,—such wind-chests have nothing to recommend them. It must also be noted that the universal or single-chambered wind-chest renders the augmentation of the treble by means of increased pressure impossible; and as long as the universal wind-chest is systematically adhered to, it is also impossible to have different pressures of wind furnished to the several stops of pipes planted thereon. As we lay infinitely more weight on the scientific and artistic production of tone than on the adoption of purely mechanical expedients, we cannot advocate the use of the single-chambered wind-chest with its several positive disadvantages.

The most remarkable development of the universal wind-chest is that patented by Mr. John Turnell Austin.* In the preamble of his English patent the following outline of his invention is given:

> "My invention has for its object to construct an Organ having a universal wind-chest which is provided with an air-tight door and of sufficient size so that a man can easily enter the same to repair or adjust any of the working parts therein. The wind-chest contains the pumping bellows and also preferably some suitable regulating apparatus to regulate the pressure in the wind-chest.
>
> "The top of the wind-chest is provided with a multiple series of apertures into which the lower ends of the pipes connect. These apertures are all controlled by valves and each series of valves is provided with mechanism for throwing them in and out of operative relation to the operating rods or tracker bars controlled by the keys, the controlling mechanism for each series of valves being operated from the stops. Thus I have a universal wind-chest having a multiple series of valve exits to the pipes, stops controlling each series of valves, and keys operating the tracker rods for actuating the valves of those series which are thrown into operative position.
>
> "The invention also includes the construction of the passage-ways through the top of the wind-chest, so that the danger of leakage from the wind-chest into the pipes is materially reduced. This is effected by forming the passage wholly in the cross-bars or scantlings in the top of the wind-chest and inserting the lower end of the pipe directly in the passage, thus formed in the scantling, so that the only joint in the passage is the one where the pipe connects into the passage in the scantling or cross-bar.

* English Letters Patent, No. 2802, dated 8th Feb., 1895. United States Letters Patent, No. 537,664, dated April 16th, 1895.

"The invention further relates to the peculiar construction of the stop-actuating mechanism for throwing in and out of operative relation the series of valves. This is preferably accomplished by supporting the valve operating levers of each stop upon a common swinging wing, which wing is moved in or out by the stop, and arranging buttons or bearings on the trackers in such relation to the valve-operating levers that when the stop is not drawn the movement of the tracker affects only such of the valve-operating levers as have been thrown into operative relation to the buttons on the tracker by drawing the stop.

"With my construction all small air passages are avoided, there is no danger of one set of pipes robbing another of wind as they are all subjected to the same pressure in the same chest."

If the reader will compare what is stated in the second paragraph of the above preamble to Mr. Austin's Patent Specification, with our description of Randebrock's invention, he cannot avoid being struck with the identicalness of the general principles of construction observed in the mechanical portions of the universal wind-chests of both builders. The great point of dissimilarity obtains in the respective dimensions of their air chambers. In Randebrock's wind-chest the chamber is just sufficiently large to convey enough compressed air to all the pipe-valves to prevent robbing and inequality in the speech of the pipes planted above them: while in the Austin chest the air chamber is made large enough to permit a man "to easily enter the same [through "an air-tight door"] to repair or adjust any of the working parts therein." Providing that the working parts are of so uncertain and delicate a nature as to require frequent repairs or adjustment, this large air chamber has much to recommend it. In addition to the space necessary for the movements of the repairing workman, the chamber is made sufficiently large, according to the Patent Specification, to contain "the pumping bellows and also preferably some suitable regulating apparatus to regulate the pressure in the wind-chest." In accordance with the Specification and the drawings accompanying the same, the chamber also contains an electric motor and the necessary mechanism for actuating the "pumping bellows." The "pumping bellows," or, in more correct terminology, the feeders, are attached to one side wall of the air chamber, and draw air from the exterior and deliver it into the interior of the chamber. As soon as the feeders deliver their compressed air, "a regulating apparatus"—attached to another side wall of the chamber, and formed of a single large inner board with stout leather folds, or light, leathered ribs after the fashion of an ordinary bellows—collapses more or less, according to the quantity of condensed air delivered by the feeders for the supply of the speaking pipes. The inside of the regulator is open to the external air, and its movable board is drawn into the chamber by weights, or forced inward by springs, so as to give the requisite pressure to the pipe-wind contained in the chamber. The action of the feeders is controlled, through the motor, by the movements of the regulating apparatus, and an escape- or blow-off valve is provided in the board of the regulator to prevent any increase of pressure obtaining in the air chamber.

It must be borne in mind that the mere size of the air chamber has no influence on the amount of compressed air supplied to the pipe-work, however much it may affect its equal distribution. All the available pipe-wind depends on the united offices of the feeders and the regulator, just as in the case of the ordi-

nary compound bellows the supply of the pipe-wind does not depend on the capacity of the receiver, but on the size and activity of the feeders attached to the same.

There is one serious objection common to all forms of the universal wind-chest, which does not obtain in the case of any form of the compartment or many-chambered wind-chest controlled by separate draw-stop ventils. In the universal wind-chest all the pipe-valves are so disposed that should any one become imperfect, or so deranged that it cannot be affected by the draw-stop mechanism, the entire division of the Organ in which that valve is located is rendered useless until it is repaired, or a new valve is fixed. In any compartment wind-chest a deranged valve merely renders a single stop useless for a time. It is a strange fact that serious derangements occur at the most inopportune times, when some special organ performance is in progress, and when there is no organ builder at hand: and such being almost invariably the case, it is questionable how far the adoption of any form of universal wind-chest is to be recommended. Perfect workmanship goes far to render serious derangements unlikely; but perfect workmanship does not prevent delicate mechanism from wearing out in the course of time.

CHAPTER XXVIII.

TUBULAR-PNEUMATIC ACTION.

THE tubular-pneumatic action has ever since its introduction in organ-building been held in high estimation by numerous English and American builders, having largely superseded the ordinary tracker and the more costly combined pneumatic lever and tracker actions; and whatever objections may be, with more or less foundation, advanced against its use in large and complicated Organs, it has certainly greatly simplified the interior arrangements of such Organs, and secured uniformity and extreme lightness of touch, advantages unknown with the ordinary tracker action, and only very partially secured with the most perfect and complete pneumatic lever action.

We cannot do better, both on historical and practical grounds, than introduce the subject of the present Chapter in the language of the person who claims to have invented the tubular-pneumatic system. In the year 1869, Mr. Edwin Horsell Pulbrook, of Tooting, Surrey, took out a patent for what appears to have been the first systematic introduction of pneumatic tubes in the Organ, for the purpose of transmitting motion between the key mechanism and that of distant wind-chests. The following is extracted from his "Provisional Specification":

"The chief object of my Invention is to enable me to dispense with much of the complicated mechanism now in use for connecting the keys with the pallets of the sound-boards. Heretofore in Organs, where the keys are placed at some distance from the instrument, motion has been communicated to the pallets from the keys by means of levers or rods known as trackers, or by electricity; now, according to my Invention, I connect the pneumatic apparatus at or near the keys with the pneumatic apparatus in the instrument, and in connection with the pallets, by means of a tube or tubes. By these means it is almost immaterial how far the keys may be distant from the instrument, for whether the keys are but a few feet therefrom, or say fifty feet therefrom, in both cases an equally light touch is obtained.

"The second part of my Invention relates to certain apparatus hereafter described for applying my Invention to Organs to enable me to work the sound-board, slides, couplers, and ventils, whether the keys are close to or distant therefrom. For this purpose I connect a backfall to each key or pedal by a sticker or tracker, over the other end of which I place a long box extending the whole length of the backfall-frame; the box is divided internally into two channels, one extending from end to end, the other being divided into as many chambers as there are keys upon the manual or pedal: each chamber is provided with two apertures, one communicating with the atmosphere, the other with the long channel from which the air is either exhausted or else filled with compressed air; in both cases it is connected by a wind-trunk to a bellows or exhausting machine. The apertures in the small chambers are governed by two disc-valves fixed on a vertical rod, which is kept in the center of the holes by guides, and is connected to the backfall by means of buttons. When at rest, the hole in the chamber communicating with the atmosphere is open, and that communicating with the air-channel is closed, and kept so by a spring placed on the backfall; but when the key is put down the resistance of the spring is overcome, and the hole communicating with the atmosphere is closed, while that communicating with the air-channel is open; the chamber now contains air of the same density as the channel; a third hole is bored in the side of each small chamber into which a tube is fixed, by means of which tube the air in this chamber can be carried any required distance. Supposing the keys have a dip of 3/8 of an inch, the valves in the chambers only require to move $\frac{1}{16}$ of an inch, thus when the key is put down $\frac{1}{16}$ of an inch the valve communicating with the atmosphere is closed. To enable a key or pedal to be put down the full distance a metal spring is fixed to each backfall and also to the vertical rod carrying the disc-valve which takes the strain from the action. If an Organ is supplied with highly compressed air for the purpose of supplying solo stops I employ the same for opening the pallets of the sound-board; beneath the wind-chest, under each pallet and connected with the pull-down thereof, is fixed a small power-bellows which when inflated draws and maintains open the pallet,.but when collapsed allows the pallet to close by the action of its spring. Each of these small bellows is connected by means of a tube to one of the small chambers before described; if now compressed air be forced into the air-channel, as soon as the key or pedal is put down the air will pass from the air-channel through the chamber and tube and inflate the small power-bellows, thereby opening the pallet. When air of a lighter density than the atmosphere is employed to open the pallets of the sound-board, the small bellows beneath the wind-chest are inverted; by exhausting the air from these bellows they will collapse and open the pallets, but when atmospheric air is allowed to enter them the pallets will close by the action of their springs and also draw open these bellows.

"For small Organs," continues Mr. Pulbrook, "I prefer to employ an improved form of pneumatic valve to open the pallets, constructed as follows:— Beneath the wind-chest and running the whole length thereof is placed a piece of wood, in which immediately under each pallet is bored a hole varying in size with the size of the pallet; another aperture in which the end of the tube is inserted is

bored communicating directly with the other hole, upon which purses, made preferably of leather, are formed having a disc at top and bottom: through the center of these discs a tapped-eye is placed and secured on each side by a button; this tapped-eye is connected by a wire to the eye of the pallet; the holes having been bored through the wood, the bottom side must be covered by a veneer. When the air is exhausted from the hole it will cause the purse to collapse and open the pallet.

" In Organs where it is necessary to economize space I employ an improved form of pneumatic lever constructed in the following manner:—Beneath the wind-chest and running the whole length thereof a piece of wood is placed; immediately under each pallet a mortise is made in this wood, into each mortise a hole is bored for the reception of a tube, the bottom side of the mortises are covered by a veneer, on the top they are covered by leather glued on; over every mortise a piece of V-shaped wood is glued and made secure at its wide end to one end of the mortise by means of a tail piece; through the narrow end (which does not quite extend to the end of the mortise) of this V-shaped piece of wood a tapped eye is passed and secured by buttons top and bottom [the V-shaped piece is laid on the top surface of the leather diaphragm and the tapped eye is secured through the same]; this eye is connected by a wire to the pallet eye. When at rest the piece of wood and covering will be held above the mortise by the spring of the pallet, but when the air is exhausted from the mortise the covering will be caused to collapse and draw open the pallet.

" My improved draw-stop action is constructed as follows:—The end of the draw-stop rod is connected to a slide working between an upper-board and table and inclosed by bearers. Beneath the table is an air chamber from which the air may be exhausted or it may be filled with compressed air. Two holes are bored through the upper-board and table into this air chamber; into the holes in the upper-board tubes are fitted; two holes are also bored through the slide so placed that only one of the holes leading from the upper-board to the air chamber is opened at one time. To allow the tubes to be in communication with the atmosphere, when the passage to the air chamber is closed, another hole is made in the upper-board between the other holes, and a slot is formed in the slide. Each sound-board slide is connected by a lever or other mechanical arrangement to the moving portion of a double bellows of the requisite size, the other ends of the tubes, fitted into the holes in the upper-board, are fitted into these bellows. If the stop is drawn 'out' and the air exhausted from the air chamber, it will also be from the upper part of the bellows, and the bellows will collapse and move the slide in the sound-board; if the stop is put 'in,' the lower part will be caused to collapse and the slide will be again moved. If compressed air be used to work the sound-board slides, the bellows instead of collapsing will be inflated.

" In Organs where the keys are placed at a considerable distance from the instrument, it may in some cases be advisable to use another form of pallet-box instead of that before described. This consists of three channels, the top and bottom channels run from end to end, the middle one is divided into as many small chambers as there are keys or pedals, from one of the channels air is ex-

hausted, the other is filled with compressed air; the chambers communicate by holes with the outside channels; the vertical rod [carrying two disc-valves] passes through a metal plate, by preference of brass, like a pull-down, and is connected to the backfall as before described. When the key is put down, the air is exhausted from the middle chamber tube, and one of the appliances before described for opening the pallets by means of air lighter than the atmosphere, which will be caused to collapse and open the pallet; when the key returns, the valve communicating with the compressed-air channel will be opened, and compressed air will be passed through the middle chamber and tube, and inflate the apparatus under the wind-chest, thereby causing the pallet to close. In a state of rest, the hole communicating with the channel from which the air is exhausted is closed by the disc-valve and kept so by the spring on the backfall, and the middle chamber is full of compressed air from the other channel, the valve of which is open. When compressed air is used to open the pallet, the middle chamber will have the air exhausted from it when at rest, and the small bellows will be kept closed till the key is put down, when the compressed air will be admitted and inflate them and open the pallet." *

It will be seen by the foregoing that Mr. Pulbrook's invention practically embraced all the essential principles upon which the many subsequent forms of the tubular-pneumatic action have been constructed. His most important "claim," as stated in his complete Specification goes to prove this fact. It is as follows:—

"The dividing of the pneumatic apparatus into two parts or portions, one part or portion containing the valves to be placed near the keys, and the other or movable part at or near the sound-board, and in connection with the pallets thereof, the two portions or parts being connected by tubes or tubing through which air is conveyed as required, and as before described."

It will only be necessary in the present treatise to clearly explain the principles upon which all tubular-pneumatic actions are designed and constructed; giving full particulars and illustrations of certain ones that present noteworthy features, and which have been found satisfactory in actual use. It would be quite impossible in the space at our disposal to describe the numerous varieties which have been introduced by organ builders in England and America, for almost every builder of note has introduced some modification in one direction or another, which in certain cases may be considered a distinction without a difference. That which virtually constitutes the tubular-pneumatic action is, however, alike in all; namely, the *pneumatic tube*, connecting the mechanical part directly and immediately controlled by the keys with the distant appliance (through any intermediate appliances) which directly commands the movements of the wind-chest pallets or valves.

There are five systems on which the tubular-pneumatic action has been con-

* The description is an indifferent piece of composition, and we have thought it undesirable to quote it verbatim or exactly as it is printed in the Letters Patent. We have omitted certain typographical errors, and have made a few minor alterations and additions to help the reader to understand (in the absence of drawings) what is aimed at in the descriptions. The English Letters Patent for Pulbrook's "Improvements in Organs" is No. 1571, dated 21st May, 1869.

structed by different builders and at different times, and in which the pneumatic tubes fulfil slightly different offices. In the first system condensed air of a higher pressure than that employed for the ordinary pipe-work is alone used, being sent from the appliance immediately controlled by the clavier, through the pneumatic tubes and any intermediate appliances, to the wind-chest, where, by forcibly inflating either leather puffs or power-bellows, it opens the pallets which admit the organ-wind to the pipe-work. The return action is accomplished by the simultaneous shutting-off of the compressed air from the tubes and the opening of a communication between them and the external air, so that they may instantly discharge the compressed air within them and allow the puffs or power-bellows at the wind-chest to collapse under the pressure of the pallet-springs. This system has not met with much favor from the fact that the condensed air is called upon to do a considerable amount of work, and, accordingly, has to be of a somewhat high pressure. Under these circumstances a special high-pressure bellows is necessary for the pneumatic action, unless it happens that wind of the required pressure is already provided for a certain section of the pipe-work. In deciding the necessary pressure two things have to be considered; namely, the power required to open the wind-chest pallets against the combined pressure of the organ-wind and their recovering springs, and the length and internal diameter of the pneumatic tubes. When both power and promptness are required with long tubes, high-pressure air is necessary, and the tubes should have a comparatively large bore. In deciding the pressure the element of friction within the tubes must not be overlooked.

In the second system attenuated air—air of much less pressure than the ordinary atmosphere—is alone used as the direct agent in the pneumatic action. This exercises a powerful suction within the pneumatic tubes, exhausting the air from the puffs or power-bellows, and allowing either the atmosphere or the condensed air within the pallet-box of the wind-chest to exert pressure on the external surfaces of these appliances, to which the wind-chest pallets are linked. In this system, which may be called the forced exhaust system, the air is attenuated or reduced in pressure through the agency of what is known as the vacuum bellows. The forced exhaust is much quicker and more energetic in action than compressed air at any practical pressure; and it is effective in proportion to the more or less complete character of the vacuum that creates it and this because it has at all times the constant pressure of the atmosphere aiding its action, to which in some cases is added the force of the ordinary organ-wind contained in the pallet-box of the wind-chest. Such being the case, the exhaust action is to be recommended where very long and small bore tubes have to be used; the necessity of having a special vacuum bellows has, however, militated against its frequent adoption. While the direct action, set up by the depression of a key, consists in making a communication between an exhaust chamber and the near end of the pneumatic tube, the return action, incident on the release of the key, consists in cutting off the communication between the exhaust chamber and the pneumatic tube and opening a communication between the end of the tube and the external air, which, rushing in, fills the tube and releases the action at the wind-chest. On account of its power, even with power-bellows of small dimensions, the forced exhaust system is admi-

rably adapted for the pneumatic draw-stop action attached to the sliders of the ordinary wind-chest.

In the third system both condensed and attenuated air are used, the pneumatic tubes being alternately charged with the former and exhausted by the latter on the depression and release of the keys. In this compound system the appliance at the wind-chest may be operated, so as to open the pallets, either through the pressure exerted by the condensed air, or through the suction caused by the attenuated air, the one in both cases operating contrary to the other. The use of both pressure and forced exhaust in the same action insures extreme promptness and certainty, and may be adopted with advantage in very large Organs, and when the claviers are placed at a great distance from the wind-chests.

In the fourth system compressed air at moderate pressure is alone used; indeed, it is, in the generality of cases, sufficient to use the wind furnished by the general bellows of the Organ. The compressed air is called upon to do very light work, having no direct communication with the motors or power-bellows which actuate the wind-chest pallets. In the most satisfactory actions, the compressed air, passed through the pneumatic tubes, simply imparts a slight movement to a leather diaphragm or small puff to which two small disc-valves are connected, the valves being so arranged that, when the action is at rest, one closes a small orifice in the valve-box which opens to the external air, while the other opens up a communication for the passage of the ordinary organ-wind to the interior of the motor or power-bellows, placed within the pallet-box of the wind-chest, and to which a pallet is linked. Under these conditions, the air within and without the motor being of the same pressure, the bellows remains expanded and inactive. On the depression of the key compressed air is allowed to enter the pneumatic tube, the puff instantly becomes inflated, and the positions of the disc-valves are reversed: the organ-wind no longer has entrance to the interior of the motor, while communication is made between it and the open air. The pressure of the organ-wind within the pallet-box immediately acts on the external surface of the motor, collapsing it and opening the pallet to which it is linked. It is only necessary in an action of this class, in which the exhaust is a natural one, for the external surface of the motor, acted on by the organ-wind, to exceed that of the pallet, similarly acted on, sufficiently to enable the motor to draw the pallet smartly from its seat, against the combined pressure of the organ-wind and its own recovering spring.

In the fifth system natural exhaust is alone made use of, the valves immediately commanded by the keys simply opening and closing the pneumatic tubes in the open air. The tubes are charged with the organ-wind from the pallet-box of the wind-chest, through the motors placed therein, and to impart the necessary activity to the motors it is only necessary to open the key end of the pneumatic tubes. The best action on this system with which we are acquainted is that patented by Mr. John Henry Odell, Organ Builder, of New York, which is illustrated and described farther on in the present Chapter.

The use of the pneumatic tube is common, and gives the name, to all the tubular-pneumatic actions that have been introduced; and beyond its dimensions and the materials of which it is made it can present no variety. The points of

difference between the several actions obtain in the manner in which the key-valves are constructed and operated, and in the peculiar formation and mode of operation of the appliances connected with the wind-chest, whereby the pipe-work is made to speak. There are also intermediate appliances, chiefly for coupling purposes, which vary in construction in the actions made by different organ builders; in the formation of these, however, a general principle is observed.

Taking the mechanical appliances which belong to the tubular-pneumatic action in proper order, we have first to consider the appliance, in its different forms, which is immediately connected with the clavier, and which commands the key end of the pneumatic tubes. This appliance may be called the key valve-box, for it contains the valves which are directly moved by the clavier mechanism, and which charge and exhaust, or simply exhaust, the pneumatic tubes in the different systems that have been introduced.

In the first system, as previously described, compressed air is alone used as the motive power; and this is sent through the pneumatic tube from the key valve-box on the depression of the key, and is subsequently allowed to exhaust itself into the open air on the release of the key. There are several modes of constructing the key valve-box for this class of tubular-pneumatic action. In Fig. CXCV. are given two Transverse Sections of valve-boxes, constructed on the lines of the key valve-box depicted in Pulbrook's Specification. No. 1 is the Transverse Section of a long box divided horizontally into two parts. The lower part A is a continuous chamber which is charged with compressed air from a high-pressure bellows. The upper part B is divided by thin, vertical partitions into as many separate chambers as there are notes in the accompanying clavier. Three holes are bored in each chamber: one communicating with the compressed-air chamber at C, one to the open air at D, and one for the reception of the pneumatic tube at E. The tube is indicated at F, tightly fitted into the hole E. G and H are two small disc-valves, formed of soft leather, thin felt, and mill-board, hard rubber, or other suitable and durable material. These are held in proper position on the wire I by four leather buttons, as shown. The wire is carried and held in position by the spring J and the backfall K, through which it passes and to which it is adjusted by the three leather buttons, as indicated. The backfall is connected, at its other end, with the tail of the key either by direct contact or by a sticker or a short tracker, according to controlling circumstances. As the motion of the valves G and H need not exceed 1/8 inch, and their end of the backfall 1/4 inch, the backfall must be so pivoted as to give its other end the motion of the key tail. The backfalls must be arranged as a fan-frame, for it is necessary for the centers of the disc-valves to be farther apart than the centers of the key tails. Springs must be applied to the key ends of the backfalls to recover, and impart the desired touch to, the keys. The operation of this appliance is extremely simple. On putting down the manual key, the end of the backfall K shown is depressed; its spring J immediately reverses the positions of the disc-valves G and H, closing the communication with the open air and opening the communication between the chambers A and B. The compressed air rushes into the chamber B and thence along the pneumatic tube F to the motor at the distant wind-chest. Any further motion of

the backfall is allowed by the spring J, as may be understood from our drawing. On the release of the manual key, the valves return to the positions shown in the Section, the compressed air is shut off, and the pneumatic tube exhausts, through the chamber B and its opening D, into the atmosphere.

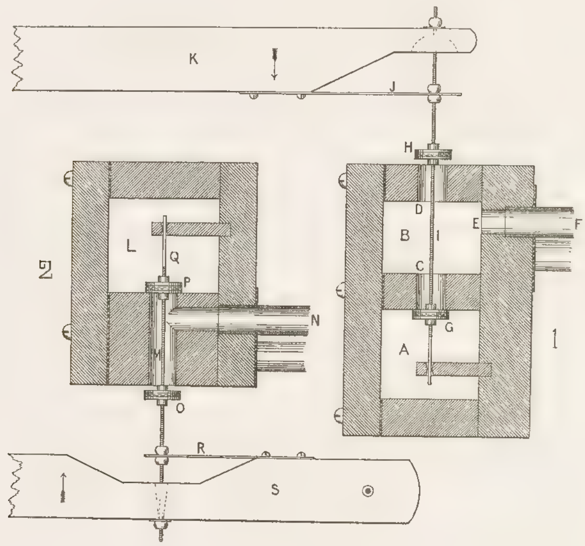


Fig. CXCV.

The Transverse Section No. 2, Fig. CXCV., is that of a key valve-box of a somewhat simpler form than the one just described. It is also for compressed air and a natural exhaust. It has only a single chamber L, which is continuous and filled with compressed air from a high-pressure bellows. The bottom of the chamber is formed of a thick piece of wood through which are bored, in the manner indicated, as many vertical and horizontal holes as there are notes in the clavier. The vertical hole M serves as the supply and exhaust channel for the pneumatic tube N, according to the position of the disc-valves O and P. These valves are carried on the vertical wire Q, which is connected with the spring R and passed through the lever S, much in the manner described in connection with the backfall K, in Section No. 1. The lever S is pivoted at one end, as indicated, while its other end rests upon, or is linked to, the tail of the manual key. The wire Q is passed through the lever at the point in its length which secures the proper motion of the disc-valves and the spring R in relation to the movement of the key tail. When at rest, the disc-valves occupy the positions shown in the Section; but when the key raises the lever S, the valve O closes, and the valve P rises, allowing the compressed air to rush through the channel M into the pneumatic tube N. In this

form of valve-box the disc-valves can be placed closer together than in the preceding form: and by widening the chamber L, and by boring the holes M and N in a zig-zag manner (or "staggered," as it is sometimes called), the valves can be placed in direct line with the centers of the manual keys, and the levers S need not be fanned.

Probably one of the most satisfactory forms of the key valve-box that has been invented is that patented in 1886 by Mr. Charles Brindley, of Sheffield, England, in which is introduced what he designates the "spring pallet." The construction of this ingenious key valve-box is shown in the Transverse Section, Fig. CXCVI. It consists of a single continuous chamber A, which is kept charged with compressed air while the Organ is in use. The bottom of this chamber is formed of a thick piece of close-grained wood, through which are carefully bored

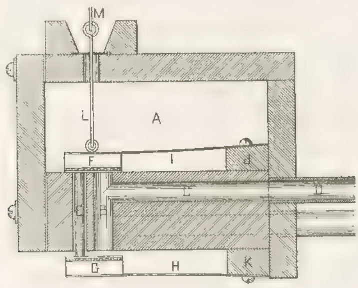


Fig. CXCVI.

one horizontal and two vertical holes for each note of the clavier. The vertical hole B and the horizontal one C are for the supply and exhaust of the pneumatic tube D. The other and smaller vertical hole is for the passage of the sticker E, which bears on both the spring pallets F and G and keeps them the required distance apart. The pallets are formed of small pieces of wood, faced with thin felt and leather, and secured to the ends of two springs H and I, the other ends of which are tightly screwed to the rails J and K, in the manner indicated. The springs are of different strengths, the one within the chamber I being sufficient to press open the pallet attached to the spring H through the agency of the small sticker E. The spring H only requires to be sufficiently strong to hold the pallet G tightly against its seat when subjected to the pressure of the condensed air through the vertical holes. The upper pallet F is raised by the pull-wire L, which passes through a brass plate and is linked to the key tail, or a lever resting thereon, by the wire M. On the depression of the key the pallet F is lifted, and the pallet G instantly closes the lower ends of the vertical holes; the compressed air rushes along the holes B and C and fills the pneumatic tube D. On the release of the key the pallet F falls, pushing down the sticker E, and opening

the pallet G, as indicated in the Section. The condensed air in the pneumatic tube immediately exhausts itself into the open air.*

A modified form of this spring pallet box was subsequently introduced and used by Messrs. Brindley and Foster, of Sheffield, which presents some advantages over the preceding form. Transverse Sections of this box, showing its relative position to the manual key tails, are given in the accompanying illustration, Fig. CXCVII. The first Section (1) shows the positions of the spring pallets when the manual key is held down; while the second Section (2) shows their reversed positions when the key is released. In general construction the box is similar to that previously described. A is the compressed-air chamber, the bottom of which is pierced with one horizontal and two vertical holes for each note of the clavier,

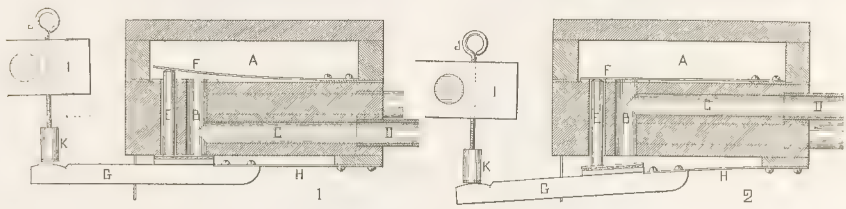


Fig. CXCVII.

exactly as in Fig. CXCVI. The holes B and C are for the passage of the compressed air to and from the pneumatic tube D, while the smaller vertical hole is for the accommodation of the sticker E. A strip of soft pallet-leather is glued along the surface of the bottom where the vertical holes are bored, and the portions covering the holes are very accurately and carefully cut out. This leather forms a bed for the spring F to rest upon when closed, as indicated in the second Section. The spring F forms the pallet or valve within the compressed-air chamber, and is made sufficiently wide to safely cover the larger hole B. As the pallets are placed in the direct line of the keys they cannot exceed $\frac{7}{16}$ inch in width, while the holes they cover must not exceed $\frac{9}{32}$ inch in diameter: the former dimension will allow a working space between the edges of the spring pallets. The lower or exterior pallet G consists of a small lever arm of hardwood, about $\frac{5}{16}$ inch thick, fastened to the metallic spring H, as indicated. On the upper face of the wood arm is securely fixed a pad of the same width as the spring pallet F, formed of millboard, felt, and leather. This covers the two vertical holes, as shown in the first Section. The spring of this exterior pallet G must be of sufficient strength to raise, when the weight or pressure of the key tail I is removed from it, the interior pallet F, and also to resist the downward pressure of the compressed air on its surface directly under the vertical holes. Through the end of the key tail I is screwed a tapped-wire J, which carries a small turned foot-piece of hardwood, faced

* This key valve-box is illustrated and described in Brindley's English Letters Patent, No, 12,211, dated September 25, 1886.

with felt, K. This is so adjusted, that when the key is not touched it rests upon, and keeps open, the pallet G, in the manner shown in the second Section; but when the key is put down and its tail raised even a short distance, the pallet instantly closes and simultaneously opens the interior pallet F. As the key is further depressed by the finger, the foot-piece K leaves the pallet arm G, as indicated in the first Section, the key tail having a greater motion than the pallet arm. In this action it is necessary for the key touch to be regulated either by springs bearing on the key tails or by weighting the tails with lead plugs.

A key valve-box constructed on the same general principle as those just described has recently been patented by Mr. William E. Haskell, of Brattleboro, Vermont.* The supply- and exhaust-valves hold the same relative positions on the upper and under faces of a perforated plank, and are connected by means of a short sticker, as in the Brindley key valve-boxes; but instead of being spring pallets or valves, they are simply small wooden levers pressed by small pallet-springs of the usual form. The only essential point of difference in the operation of the respective valve-boxes lies in the fact that the Brindley valve-boxes leave the pneumatic tubes exhausted when the spring valves are unmoved by the key action, while in the Haskell valve-box the pneumatic tubes are charged with compressed air so long as the valves are unmoved by the key action. In other words, the Brindley key valve-boxes belong to the pressure tubular-pneumatic system, while the Haskell valve-box belongs to the exhaust tubular-pneumatic system.

Several other key valve-boxes have been constructed on the same principles as those which obtain in the appliances above described; but it is unnecessary to devote space to them here. Others have been constructed on the principle of the slide-valve of the steam engine, in which a small slide-valve is provided for each note, which, on the depression of the key, is moved so as to admit the compressed air to the pneumatic tube; and, on the subsequent release of the key, returns to its original position, connecting the entrance of the pneumatic tube with the exhaust or open-air port. The slide-valve is formed of boxwood or beech, and works on a flat, black-leaded surface in which the supply and exhaust ports are pierced. The slide-valve is usually held in position by one or two small spiral springs.† While, from a mere description, this form of valve may appear suitable, it has never been found to be so for the quick motions of the manual keys: on the other hand, it has been successfully used in certain tubular-pneumatic draw-stop actions.

In the second system, in which attenuated air is alone used as the active agent in the manner previously described, the key valve-box may be constructed on lines very similar to those obtaining in the illustrations above given, it being only necessary to reverse the positions of the valves, so as to secure certainty and promptness of action. While in the appliance in which compressed air is alone used the supply valve is placed *within* the compressed-air chamber, so that when the action is at rest the pressure of the air may tend to keep the valve tightly closed; in the appliance in which attenuated air is alone employed as the active agent, the valve which

* "Pneumatic-valve for Organs" United States Patent, No. 760,114, dated May 17, 1904.

† Illustrations of these valves, applied to the manual key action, are given in Töpfer-Allihn's "Die Theorie und Praxis des Orgelbaues"—(Edition, Weimar, 1888): Figs. 7 and 8, Plate XLI.

controls it should be placed *outside* the attenuated-air chamber, so that the powerful inward suction, or, correctly speaking, the pressure of the atmosphere on the outer surface of the valve, may tend, when the action is at rest, to keep the valve air-tight against its seat.

It is only necessary, to prevent any misunderstanding in this matter, to give one illustration of a key valve-box for the attenuated-air or forced-exhaust system. The accompanying illustration, Fig. CXCVIII., is a Transverse Section of such a valve-box. The appliance consists of a long box divided horizontally into two parts. The upper part A is a continuous chamber, from which the air is exhausted by the operation of a vacuum bellows. The lower part B is divided by thin vertical partitions into as many small chambers as there are notes in the clavier. Three

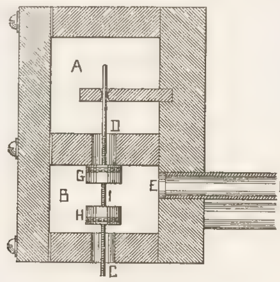


Fig. CXCVIII.

holes are bored in each of these chambers, as indicated; the hole C communicates with the external air; the hole D communicates with the attenuated-air chamber; and the remaining hole E is for the reception of the end of the pneumatic tube F. The two small disc-valves G and H are formed and fixed on the vertical wire I in the manner previously described. The lower end of the wire is attached in any convenient manner to the manual key action, so that it will be drawn down when the key is depressed and returned when the key is released. When the wire is drawn down, the valve G opens the hole D, and the valve H closes the hole C; and the air in the chamber B and in the pneumatic tube F is immediately and forcibly sucked out or exhausted. On the return of the action, the valves resume the positions indicated in the Section, and the external air rushes in through the hole C and fills the partial vacuum created by the forced exhaust. Spring pallets or valves of any desirable form may be used in this as in the compressed-air valve-box.

In the third system, in which both condensed and attenuated air are used as active agents, the key valve-box may be constructed in the manner indicated in the Transverse Section, Fig. CXCIX. It is simply a combination of the pressure and forced-exhaust boxes shown in Figs. CXCV. and CXCVIII. This compound valve-box is divided horizontally into three parts, the upper and lower ones being continuous chambers, while the middle one is divided vertically into as many small

chambers as there are notes in the accompanying clavier. The continuous chamber A is that from which the air is exhausted by the action of a vacuum bellows; while the continuous chamber B is charged with compressed air, usually from the ordinary bellows of the Organ, as a heavy pressure is rarely necessary when attenuated air does the most important work. The small middle chamber C communicates with the upper and lower chambers by the circular holes D and E, and has a third hole F for the reception of the pneumatic tube G. Within the small middle chamber are two disc-valves, H and I, screwed in proper position on the vertical valve-stem J, which is held in position by the perforated strip of wood K, and by passing, air-tight, through the brass plate L. The wire is linked to the backfall M in the manner already described in connection with Fig. CXCV. It can, however, be

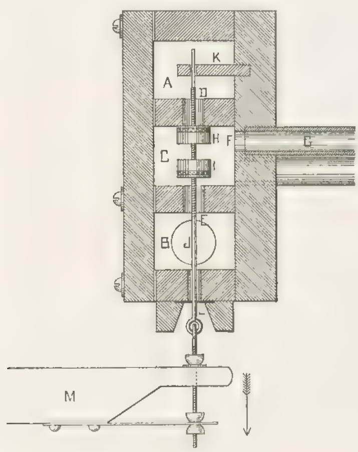


Fig. CXCIX.

attached to the key action in any other manner circumstances may direct. When at rest, the apparatus stands as shown in the Section, the upper valve H being held firmly against its seat by the spring of the key action and the pressure of the compressed air on its under surface; and the lower valve I, being raised from its seat, admits the compressed air from the chamber B into the chamber C, and thence into the pneumatic tube G. On the depression of the key, the end of the backfall M is lowered, and the positions of the valves are reversed; the compressed air is shut off from the chamber C, and the forced exhaust instantly extracts the air from it and the pneumatic tube G. On the release of the key the valves return to their original positions, aided by the pressure from the lower chamber, and the strong suction created by the vacuum bellows through the upper chamber.

The action of this valve-box, as well as that of those previously described, may be horizontal instead of vertical, a square being substituted for the backfall. Small

hinged pallets may be used in this as in the valve-boxes of other systems ; and they must occupy the same positions with relation to the compressed- and attenuated-air chambers as the disc-valves do in Fig. CXCIX., the forced exhaust being more powerful in operation than the compressed air.

Seeing that the fourth system of tubular pneumatics differs from the first only in the pressure of the wind employed, it is obvious that the same description of key valve-box is suitable for both systems. Accordingly, for this system either of the valve-boxes illustrated in Figs. CXCV. and CXCVI. may be adopted. But as wind of the ordinary pressure used for the pipe-work of the Organ is employed for the pneumatic action, it is desirable to have pneumatic tubes of larger bore than is necessary for either the high-pressure or forced-exhaust systems ; and at the same time it is desirable to have a freer entrance and exit for the compressed air to and from the pneumatic tubes. Under these conditions long and narrow hinged pallets, commanding oblong openings, will be found preferable to disc-valves which, if made sufficiently large, occupy more space than can be conveniently allowed them in manual clavier valve-boxes.

While it is true that in this system the compressed air has usually no work to do beyond inflating a small puff or motor, which operates a relay or secondary appliance attached to the wind-chest, it is desirable to confine the system to small Organs or to those in which the wind-chests are located at short distances from the key valve-boxes.

In the fifth system, in which natural exhaust is alone used to control the pallets of the wind-chest, the key valve-box is a very simple appliance : its valves, which are directly connected with the keys, have merely to open and close the near ends of the pneumatic tubes in the free air. The compressed air, which is allowed to escape or exhaust itself into the surrounding air on the opening of a key-valve, is furnished by the organ-wind in the pallet-box of the distant wind-chest, in which are placed the pneumatic levers or motors for actuating the pallets which supply the pipe-work. As before stated, the most satisfactory action on this system is that invented and patented by Mr. John Henry Odell,* of the firm of J. H. & C. S. Odell, Organ Builders, of New York : its simplicity, durability, and easy adjustment, combined with its promptness of operation and good repetition, place it in the front rank of tubular-pneumatic actions for slider wind-chests.

In Fig. CC. are given two Transverse Sections of simple appliances suitable for use in a natural exhaust tubular-pneumatic action such as that just alluded to. In the Sections are shown different dispositions of the pallets or valves which are located close to, and are actuated by, the manual keys. The key valve-box represented in the upper Section (1) consists of a thick board A, across which are bored as many channels as there are notes in the clavier, the inner ends of which are opened to the under side of the board. One of these channels is indicated at B. To the outer ends of the channels are attached the near ends of the pneumatic tubes, as at C. To the edges of the board A are attached two pieces D D to support the under board E, forming a continuous chamber open to the air at both

* "Organ-Action," United States Letters Patent, No. 609,291, August 16, 1898.

ends. Within this chamber are fitted small pallets F, one to each air-channel, in the manner shown in the Section. Each pallet has a spring G of sufficient strength to keep it firmly closed against the downward pressure of the ordinary organ-wind in the channel B; and, is fitted with a pull-down H, which is directly connected with the key action. When the appliance is at rest, as indicated in the Section, the pneumatic tube C and the corresponding channel B are filled with the ordinary organ-wind supplied from the interior of the pallet-box of the distant wind-chest. On the depression of the manual key the pallet F is drawn downward from its seat, and the compressed organ-wind in the pneumatic tube C is allowed to discharge or exhaust itself through the channel B into the open chamber below. Immediately the exhaust takes place, the pneumatic appliance situated within the pallet-box of

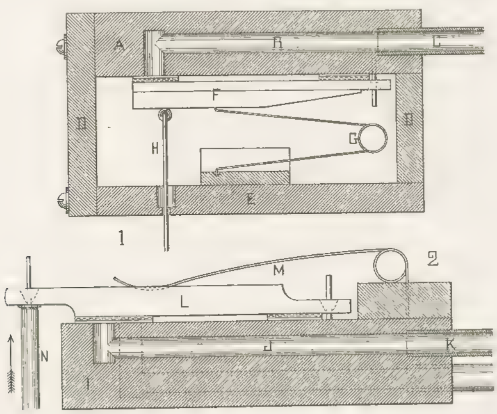


Fig. CC.

the wind-chest acts and opens the wind-chest pallet to which it is linked. On releasing the key, the valve F closes the channel B, the pneumatic tube becomes filled with the organ-wind, and the whole pneumatic action resumes its state of rest, allowing the wind-chest pallet to close and shut off the wind from the superposed pipes. The manner in which this natural exhaust operates will be found described farther on in the present Chapter. The simpler appliance represented in the lower Section (2) consists of a thick board I, across which are bored air-channels for the reception of the pneumatic tubes, as indicated at J and K. The free end of each channel is controlled by a valve of felt and leather, which is glued to the under side of a small lever, held in position by a tail-pin, and pressed by a pallet-spring. The lever and its spring are shown in position at L and M. The lever overhangs the channel-board to receive the sticker N, which rises directly from the tail of the manual key. If more convenient, the lever may be pulled up by a wire attached to the key. In this case the appliance will be located below the

manual clavier. Should it be found desirable to place the appliance immediately opposite the clavier, the projecting ends of the levers may rest directly on the tails of the keys, being prolonged from the line of the channel-board for that purpose. The operation of this appliance is similar to that previously described.

Leaving the key valve-boxes, we come, in the proper order of things, to the pneumatic tubes which connect them with the appliances attached to the wind-chests. Little need be said on this subject, for, like all round metallic tubes, the pneumatic tubes employed in organ-building differ among themselves only in size and material. The chief desiderata are that the tubes shall be light and durable, and easily cut and bent. The tubing which meets all these conditions is that made of block-tin or tin with a moderate percentage of pure lead, drawn as thin as is compatible with firmness and durability. Tubing of this character is now specially manufactured for the organ builder, in whose opinion it has no disadvantage save that of expense. The size of the tubing commonly used ranges, according to circumstances, from ¼ inch to ⅜ inch internal diameter. Larger sizes are very rarely used for key actions, and only in exceptional cases for draw-stop actions.

The tubing can be easily cut with a fine saw or a knife, and bent in any direction without damage, allowing that the turns are not too quick. When quick turns are necessary, the parts should be filled with fine, dry sand and plugged up; the bending can then be made without fear of the tubing crinkling or collapsing.

A very thin brass tubing, furnished with special junction pieces and bends, has been introduced in Germany, but it is not suitable for long-distance pneumatic work. Its durability is more than doubtful.

Several methods are adopted in securing the ends of the pneumatic tubes in the holes bored to receive them. When the hole is bored the exact size of the tube, little is required beyond a thin washer of leather, glued over it, and subsequently pierced and driven tightly within the hole. The tube has simply to be slightly waxed and pressed into the hole, a firm and air-tight attachment being the result. Some organ builders use metallic cups or rings, in which the pneumatic tubes are securely held by having their ends expanded before they are fixed in the woodwork. When the tubes lie horizontally, or nearly so, the first-mentioned attachment may be used; but when they are in a hanging position, a very secure attachment is absolutely necessary. Long pneumatic tubes should be well supported in all places where they are likely to bend or drop; otherwise they are very liable to become disconnected and cause serious derangements.

In deciding the size of tube to adopt, the length of the tube and the force of the air current within it must be carefully considered. The amount of friction in proportion to the amount of air passing through the tube is also a factor of importance. In the case of pressure pneumatic actions a larger size of tubing is required than in the case of those on the forced-exhaust or so-called vacuum systems; for in the latter the operation is more energetic, and friction is reduced to a minimum. The nature of the appliance situated at the distant wind-chest has considerable influence in deciding the size of the tubing, because it may or may not demand much wind to actuate it. This will be understood on reference to the descriptions of the several wind-chest actions hereinafter given.

Various opinions obtain among organ builders respecting the maximum safe length for pneumatic tubes; but no hard and fast rules can be given, for it is obvious that it depends upon three things in every instance; namely, the size of the tube, the force of the pressure or exhaust, and the nature of the pneumatic motor or other appliance used. Under favorable circumstances tubes of thirty feet may be safely adopted, while those of greater length have been successfully employed.

Having described and illustrated the several representative forms of key valve-boxes, or the appliances directly commanded by the claviers for the purpose of charging or exhausting the pneumatic tubes, we now come to the consideration of the appliances attached to, or directly connected with, the wind-chest upon which the pipe-work is planted, and through the agency of which the pallets or valves that admit the wind to the pipes are actuated—the appliances to which the pneumatic tubes, carried from the key-valves, are attached.

In the case of these wind-chest appliances the chief elements of success lie in the simplicity of their construction and the lightness and promptness of their action. It is essential that whether compressed air or exhaust is used it must be called upon to do very little direct work. This consideration has led to the introduction of simple auxiliary appliances, commonly known as primary pneumatics or relays: these have a very slight motion and very little work to do, being generally confined to bringing into active operation a more powerful pneumatic mechanism, or simply allowing such a mechanism to act under the influence of the organ-wind in the wind-chest or from the main reservoir.

The simplest form of the wind-chest appliance is that illustrated and described in Pulbrook's Patent, before alluded to and quoted from. This is a small power-bellows, directly linked to the pull-down of the pallet, and fixed, a short distance below the pallet-box of the wind-chest, upon a thick bearer, bored or channeled for the reception of the pneumatic tube and for communication with the interior of the power-bellows. When compressed air and natural exhaust are used, the power-bellows must be fixed to the under side of the bearer: in this position it will expand downward, in opening the pallet, under the action of the compressed air conveyed into it by the pneumatic tube. When the compressed air is shut off and the natural exhaust is opened, the bellows instantly collapses under the upward pull of the pallet-spring.

In this primitive form of tubular-pneumatic action, high-pressure air must be employed, otherwise the power-bellows would have to be made of an inconvenient size, and require too large a supply of air for its inflation. The bellows must exercise sufficient power to readily overcome the strain of the pallet-spring and the pressure of the organ-wind on the under side of the pallet; and it must be quickly inflated with the minimum supply of wind.

When forced exhaust is employed in this simple action, the power-bellows is fixed on the upper side of the channeled bearer, and collapses as it opens the wind-chest pallet. It is shown in this position in Pulbrook's Patent Specification. The action of the power-bellows is more energetic with forced exhaust than with compressed air; and under ordinary conditions the bellows can be made

much smaller. The creation of a partial vacuum within the bellows allows the external air to act on its outer surface with the force of many pounds, proportionate to the extent to which the exhaust is carried by the vacuum bellows.

Although already alluded to in the quotation from Pulbrook's Specification, given in the early part of the present Chapter, there is his exhaust pneumatic appliance which, on account of the principle involved, deserves further notice here. A Section and Top View of this appliance are given in the accompanying illustration, Fig. CCI. The pallet-box of the wind-chest is shown at A, with the

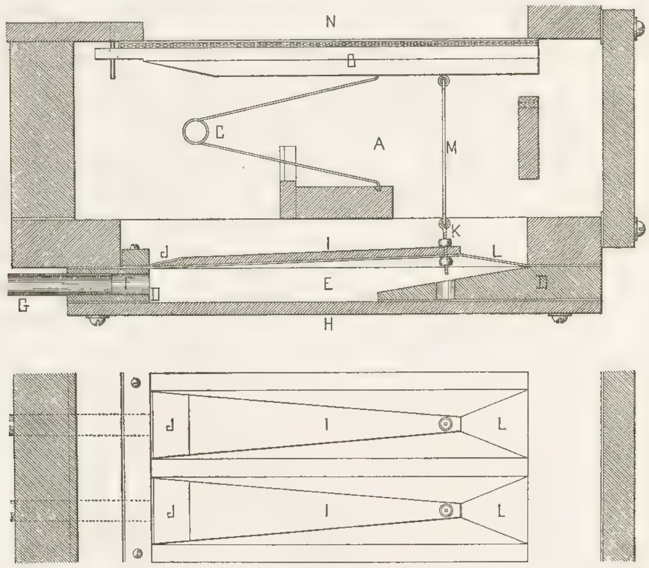


Fig. CCI.

ordinary groove-pallet B held firmly against its seat by the spring C. Along the entire length of the pallet-box is an opening for the reception of the series of pneumatic motors, one for each groove-pallet. This is covered below by a thick board in which narrow, long perforations are made transversely, directly under the several pallets, leaving a thin partition between them; and through one edge of the board a hole is cut into each of the oblong perforations for the reception of the pneumatic tube. This board is indicated at D; one of the transverse perforations at E; and the hole for the pneumatic tube at F. The end of the tube is shown at G. The under side of the board is faced with soft leather and covered by the veneer H, screwed on air-tight. The upper surface of the board is covered with thin soft leather, securely glued to the sides and partitions, and ex-

tending over all the oblong perforations. On the upper surface of the leather over each perforation, E, is glued a thin, tapered piece of wood I hinged as indicated at J. Through the small end of the piece I is passed the short, eyed tapped-wire K, secured by two leather buttons, as indicated. By this arrangement the flexible leather L, which extends over the oblong perforation E, admits of being raised and depressed to the limited extent allowed by the fixed play of the groove-pallet B, and accordingly forms a diaphragm motor. It is linked to the pallet B by the wire M, and is drawn up by the force of the pallet-spring, which, when forced exhaust is alone used, must be sufficiently strong to overcome the downward pressure of the organ-wind contained in the pallet-box A. When both forced exhaust and compressed air are alternately used, the spring has nothing to do beyond raising and holding the pallet B in its place. In such an action as this it is advisable to use both exhaust and compressed air when the pneumatic tubes are of a considerable length, otherwise satisfactory repetition is practically impossible. The operation of the appliance under forced exhaust alone is very simple: the instant the key action opens a communication between the vacuum bellows and the pneumatic tube G, the air in the chamber E is sucked out, the diaphragm L is forced downward by the organ-wind in the pallet-box A, and the pallet B is opened, admitting wind to the wind-chest groove N. On the return of the key action, communication is opened between the open air and the pneumatic tube, and all suction ceases in the chamber E, allowing the spring to draw up the diaphragm and reseat the pallet, as indicated in the Section.

When both forced exhaust and compressed air are used, the latter takes the place of the ordinary air, and forces the diaphragm upward, insuring promptness of repetition. As before remarked, this appliance, which was included in the first patent taken out for a tubular-pneumatic action, is chiefly interesting on account of the principle it embodies.

Compressed air is efficacious when used only for light work, such as the inflation of puffs, either in the form of flexible diaphragms or very small bellows; and when so used it is attended by natural exhaust. The arrangement shown in the accompanying illustration, Fig. CCII., affords an example of the use of the diaphragm puff, actuated by compressed air conveyed by the pneumatic tube. In this wind-chest appliance the heavier work is done by the organ-wind contained in the pallet-box of the wind-chest. The pallet-box is shown at A, and is of the ordinary construction. B is the ordinary pallet, held against the opening of the wind-chest groove C by the spring D. Directly below the pallet is fixed the small bellows E, linked to it by the pull-down F. Two holes are bored through the bottom of the pallet-box at G and H: the former communicating with the interior of the bellows E through a corresponding hole in its bottom-board, as indicated. Underneath the pallet-box is attached the valve-box I, divided transversely into as many small chambers as there are pallets in the pallet-box. Three holes are bored in each chamber: two communicating with those in the bottom of the pallet-box, and the third communicating with the external air at J. The circular valve K, formed of small discs of felt and leather glued to a central disc of wood, is screwed on a wire, and supported so as to move vertically between the holes H and J, as

shown. Below the valve-box is placed a thick board in which are formed a series of small diaphragm puffs; and into these are bored holes for the reception of the ends of the pneumatic tubes. One of these puffs is shown in section at L, with the entry of its pneumatic tube in the hole M. Resting on the upper surface of the leather diaphragm is the block N, secured to the wire stem of the valve K. This block should be of sufficient weight to depress the diaphragm and close the valve K promptly; or a light wire spring may be used for this purpose.

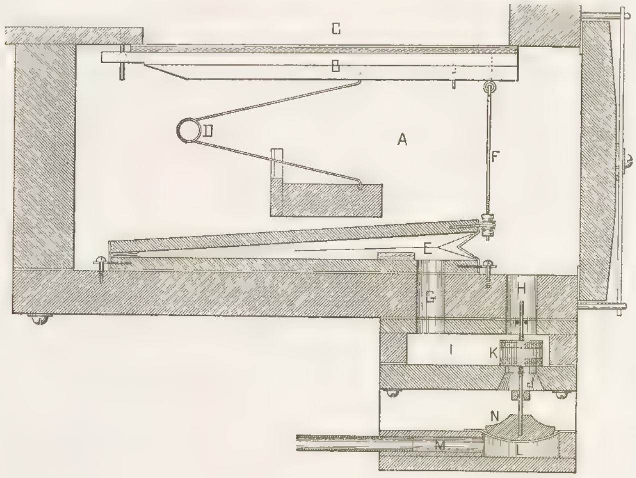


FIG. CCII.

When the appliance is at rest, all its parts occupy the positions shown in the illustration. The bellows E is expanded by the upward pull of the pallet and its spring D, being filled with wind from the pallet-box A, which passes freely through the chamber I and the holes H and G. The air within the puff L is the same as the external air, with which the pneumatic tube communicates through the key valve-box at its other end. On the depression of the distant manual key, compressed air is admitted to the pneumatic tube, and the puff L is instantly inflated, raising the block N, forcing the valve K tightly against the hole H, and shutting off the organ-wind in the pallet-box from the chamber I; at the same time the exhaust hole J is uncovered. The pressure of the organ-wind on the external surface of the bellows E causes it to collapse, forcing the air within it through the chamber I and out at the exhaust hole J. In collapsing the bellows draws down the pallet B and admits the organ-wind to the wind-chest groove C.

In this appliance it is only necessary to make the motor-bellows of sufficient size to overcome the pressure of the organ-wind on the under side of the pallet, and the upward force of the spring upon it. Any one of the simpler forms of the

relief-pallet, described in the Chapter devoted to that appliance, may be employed in connection with this pneumatic action, whereby the size of the motor-bellows may be considerably reduced, and a more satisfactory repetition obtained.

On releasing the manual key the compressed air is cut off from the pneumatic tube at the key valve-box, and communication is made with the open air. The puff L falls under the weight of the block N and the valve K, aided by the pressure of the organ-wind through the hole H.

The organ-wind again enters the bellows through the chamber I and the hole G; and an equilibrium being established, the spring instantly closes the pallet B and expands the bellows. The appliance returns to rest, and all its parts take the relative positions shown in the illustration, Fig. CCII.

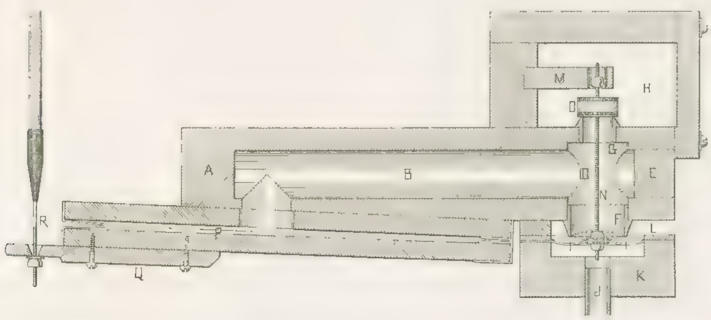


Fig. CCIII.

In Fig. CCIII. is given a Longitudinal Section of a tubular-pneumatic motor or lever devised to operate directly on a pallet of a slider wind-chest. This appliance was invented by Mr. Vincent Willis, of London, and patented by him in 1899.* It is located close to the wind-chest, and is actuated by two pressures of wind, that sent through the pneumatic tube being somewhat higher than that required to expand the power-bellows. For the latter the ordinary pipe-wind is sufficient, allowing that the power-bellows has a larger effective area than the under surface of the wind-chest pallet. The construction of the appliance is extremely simple, and may be described as follows: A is a thick plank, preferably of bay-wood, bored with the horizontal channel B and two vertical openings, as indicated. The horizontal channel is plugged at E. In the lower part of the opening D is fixed the metal valve seat F, while in the smaller opening bored through the plank is fixed the metal valve seat G. H is the condensed-air chamber charged with the ordinary pipe-wind from the main reservoir. K is a block of wood having a circular sunk chamber for the reception and support of the leather diaphragm or puff I, and for the entry of the pneumatic tube J which conveys the wind of higher pressure from

* "Improvements in Pneumatic Apparatus for Organs." English Letters Patent, No. 12.917, dated June 21, 1899.

the distant key valve-box. Between the upper surface of the puff and the under surface of the plank A, and around the valve seat F, is a space open to the external air, as indicated at L. In the center of the leather diaphragm is firmly secured the valve-stem N, which carries near its upper end the disc-valve O, and which is held in a vertical position by the small ball within a smooth metal tube in the support M, as clearly shown. The disc-valve is formed of light wood, faced below with leather and thin felt, and above with felt only. Attached to the under side of the plank is the power-bellows P, having an opening to its interior corresponding to that from the channel B. To the bottom-board of the bellows is attached the arm Q which engages the pull-down wire or tracker R. The action of the appliance (shown at rest in the Section) is as follows: When the manual or pedal key is depressed, the high-pressure air rushes through the tube J into the chamber under the diaphragm I and drives it tightly against, and some distance into, the valve-seat F, as indicated by the dotted lines. This action forces the disc-valve O from its seat until it is arrested by the support M. The condensed air in the chamber H rushes through the valve seat G, the channel B, and the end opening, and inflates the power-bellows P. When the key is released, the air exhausts through the pneumatic tube J; the diaphram falls; the disc-valve O shuts off the wind from the chamber H; and the power-bellows collapses under the pull of the pallet-spring, the air within it escaping through the channel B and the valve seat F into the open air at L. The appliance returns to the condition represented in the Section. The construction seems faulty inasmuch as the power-bellows is not furnished with an internal throttle-valve to properly arrest its inflation. The application of such a valve would be extremely simple.

In the year 1894, Mr. Peter Baggstrom, of Brooklyn, New York, took out Letters Patent for what he describes as "A new and improved Tubular-Key and Pneumatic-Valve Action for Organs."* In the Patent Specification he says: "My invention relates to a tubular-key and pneumatic-valve action for Organs, and it has for its object to so construct the valve arrangement in the wind-chest, and to so manipulate said valves from the keys that a light touch on the latter will produce a prompt speech from the tubes [pipes], the action being particularly advantageous for utilizing the coupling at present universally used between the several key-boards. And a further object of the invention is to so improve upon the valve action for Organs that the said action will need no regulation, since there will be comparatively nothing in its structure to get out of order."

In this tubular action natural exhaust is alone provided for in the key valve-box, all the condensed air which enters the pneumatic tubes being supplied from the organ-wind in the pallet-box of the wind-chest. It is the exhausting of this at the key valve-box, that imparts movement to the appliance inclosed in the pallet-box. A Vertical Section of this appliance is given in Fig. CCIV., and its mode of operation may be thus described: The pallet-box of the wind-chest is shown at A, and the wind-chest groove at B, the opening in the latter being covered by the pallet C of the ordinary form and construction. The spring D, which

* "Tubular-Key and Pneumatic-Valve Action for Organs." United States Patent, No. 525,578, dated September 4, 1894.

rests on the bearer E, holds the pallet tightly against its seat, and also expands the power-bellows F, which is linked to the pallet by the wire G. The bellows F is constructed in the ordinary manner, having top- and bottom-boards hinged and otherwise connected with thin, flexible leather. The bottom-board is in this case made of sufficient thickness to admit of the channel H being formed in it, as indicated, and is attached to the veneer which forms the bottom of the channel, and projects at each end so as to provide a ready fixture for the whole appliance by means of the two screws J and K. On removing the front-board M, disconnecting the pallet-spring D, and drawing the screw K, the entire appliance, including the pallet, can be easily taken out for examination and repairs, and just as easily replaced. At the end of the channel H are the two circular openings L and N : the former communicating with the interior of the pallet-box, and the latter with the open air through the larger exhaust opening in the bottom of the pallet-box at O. In front of the bellows F is constructed the raised portion P, attached to the bot-

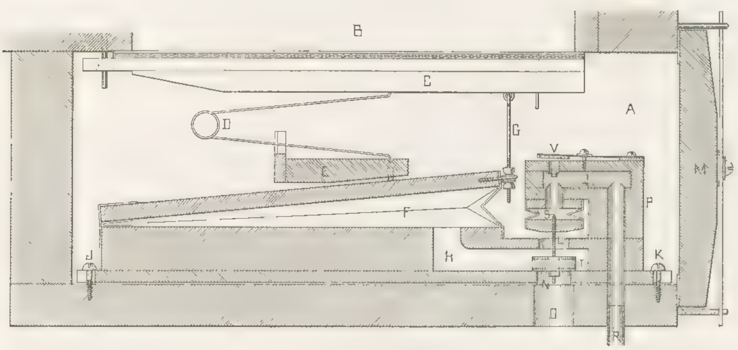


Fig. CCIV.

tom-board of the bellows, and in which the bent channel Q is formed, communicating with the perforation in the bottom of the pallet-box which receives the end of the pneumatic tube R. The channel opens at its inner end into the small pneumatic motor S. This motor carries on a tapped-wire the disc-valve T, located within the channel H and between the circular openings L and N. The collapsing and expanding of the motor alternately opens and closes these openings by means of the disc-valve T. There is a small perforation made at U, which forms a communication between the interior of the pallet-box A and the channel Q : over this perforation is placed the small valve V, carried on a light spring in the manner indicated. The construction of the appliance having been explained, we have only to consider the manner in which it operates.

In the Section, Fig. CCIV., the appliance is shown with all its parts at rest, while the pallet-box is filled with the organ-wind. In this state the organ-wind has entered the orifice U, and filled the channel Q, the pneumatic tube R, and the

small motor S, allowing the disc-valve T to seat itself over the exhaust opening O: at the same time the wind has entered the channel H and filled the bellows F, allowing it to be expanded under the force of the spring D acting on the pallet C. Now, when the manual key is put down, and the end of the pneumatic tube R is opened so as to allow it to exhaust into the open air, three separate movements instantaneously take place in the appliance within the pallet-box. The valve V closes by the rush of the organ-wind into the exhausted channel Q; the pneumatic motor S collapses by the upward pressure of the wind, moving the disc-valve T tightly against the opening L and uncovering the lower opening N; and this is instantly followed by the collapse of the bellows F, pressed down by the organ-wind while the air within it is exhausted through the orifice N. The collapse of the bellows opens the pallet C and admits the wind to the wind-chest groove B. On the release of the manual key the adjacent end of the pneumatic tube is closed, and as all exhaust here is stopped, the valve V is lifted by its spring, admitting the organ-wind into the channel Q and the small motor S. The latter is expanded by the pressure of the wind on the disc-valve T aided by the weight of the valve, tapped-wire, and the bottom-board of the motor. The organ-wind now rushes through the opening L into the bellows F, instituting a state of equilibrium, and allowing the bellows to expand and the pallet C to close, all as indicated in the Section.

We are of opinion, judging from our study of pneumatic actions, that the appliance just described would operate in a more satisfactory manner if both compressed air and natural exhaust were employed. Instead of filling the motor S, and the entire length of the pneumatic tube R (which, in some instances, might extend a considerable distance from the appliance) with compressed air through the small orifice U, it would be better to close this orifice, and to send compressed air through the pneumatic tube R from the key valve-box. This air would have to be of a higher pressure than the organ-wind in pallet-box A, so as to immediately expand the pneumatic motor against the force exercised by the organ-wind. The natural exhaust would act in this case precisely as previously described.

We now come to the tubular pneumatic action invented by Mr. John Henry Odell, of New York, and patented in 1898.* This action has been proved in actual use to be reliable and highly satisfactory. It has the advantage which no other inclosed action of the class, known to us, possesses; namely, of being easily and accurately adjusted from the outside of the pallet-box while the organ-wind is in. By means of this adjustment perfect regularity can be obtained in an Organ in which different lengths of tubing are used. Mr. Odell, in his Specification, says: "The object of the invention is to provide a new and improved organ-action arranged to render the workings of the pallets very positive, and at the same time permit a convenient adjustment of the working parts from the outside of the Organ to give any desired degree of sensitiveness to the action." This, as in the case of the action invented by Mr. Baggstrom, only calls for natural exhaust at the key valve-box. See Fig. CC.

* "Organ-Action." United States Patent, No. 609,291, dated August 16, 1898.

In the accompanying illustration, Fig. CCV., is given a Transverse Section of the pallet-box of a wind-chest, in which appears the Longitudinal Section of the pneumatic appliance. The interior of the pallet-box is shown at A, and the wind-chest groove at B, the wind-way of the latter being covered by the pallet C, of the usual form, hinged at one end, and linked at the other to the top-board of the bellows or motor D. The spring E presses the pallet firmly against its seat on the wind-chest bars, and, accordingly, holds the bellows in the inflated position shown in the Section when the appliance is at rest. The bellows is mounted on a block formed of the two pieces of wood F and G, screwed together with skiver between them, as indicated; and the block is screwed to the thick bottom of the pallet-box

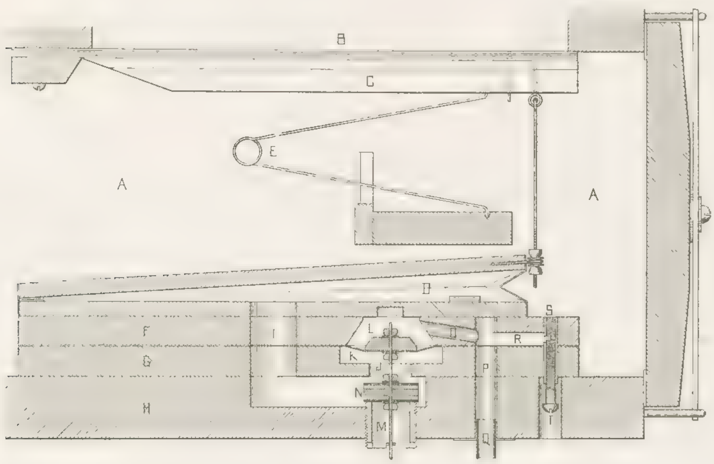


FIG. CCV.

H, which forms an important portion of the appliance. Several channels and openings are formed in the pieces F, G, and H, for the supply and exhaust of the organ-wind. The channel I opens into the motor D, and at its other end has two circular orifices, the upper one of which, J, allows the organ wind from the interior of the pallet-box to pass into the motor. The part K is cut entirely across the piece G, for the purpose of admitting the wind to the orifice J, and for the operation of the small diaphragm pneumatic constructed across the chamber L. The diaphragm is simply the skiver, which extends across the chamber, and which is securely glued to the under side of the piece F. The orifice which extends downward from the lower end of the channel I and communicates with the external air is fitted with the short brass tube M, threaded on its outside so as to admit of being raised or lowered in the adjustment of the appliance. The upper rim of this tube forms the under seat for the disc-valve N, while the lower edge of the orifice J forms its upper seat. The only communication with the chamber L is

through the channel O, which extends between it and the vertical perforation P. In the lower end of the latter is inserted the pneumatic tube Q, which extends from the key valve-box. Communication is instituted between the interior of the pallet-box A and the channel O through the opposite channel R and the perforation S. In this perforation is fixed a brass tube containing the adjusting screw T, by means of which the vent cut in the side of the tube opposite the channel R is opened to any desirable extent. It is through this vent that the organ-wind is supplied to the chamber L, instituting an equilibrium, when the key action cuts off the natural exhaust in the pneumatic tube Q.

In the Section, Fig. CCV., the appliance is shown as at rest, the organ-wind filling both the chamber L through the perforation S, and the bellows D through the orifice J, the natural exhaust in the pneumatic tube being cut off at the key valve-box. Motion is imparted to the appliance in the following manner: When, on the depression of the manual key, the end of the pneumatic tube, located in the key valve-box, is opened so as to allow the natural exhaust to take place, all resistance is removed in the chamber L, and the organ-wind which passes through the perforation S is conveyed away through the open pneumatic tube Q. The organ-wind in the open passage K instantly exerts its full pressure on the under surface of the diaphragm, driving it upward into the exhausted chamber L, and at the same time lifting the disc-valve N from the exhaust tube M and bedding it tightly against the orifice J. The organ-wind is now cut off from the channel I and the bellows D, while the channel is opened to the external air through the tube M. The compressed air immediately exhausts itself, and the full pressure of the organ-wind within the pallet-box is exerted on the outer surface of the bellows, drawing down the pallet C. So prompt are all these movements that, with a pneumatic tube of reasonable length, a perfect repetition can be obtained. On releasing the key and closing the pneumatic tube, equilibrium is again established between L and K, the disc-valve falls upon the tube M, stopping the exhaust there, and the organ-wind again rushes into the channel I and allows the spring E to close the pallet C and expand the bellows.

In this, as in all pneumatic actions in which the organ-wind in the pallet-box of the wind-chest is the motive power, it is necessary for the motor to have a surface of sufficient size to overcome, under the pressure of the organ-wind, the pressure exerted on the closed pallet and the force of its spring.

In wind-chests of proper dimensions there is no difficulty of placing motors, such as above described, in a single row throughout the bass and tenor octaves; but in the higher octaves it is necessary to arrange them in two rows, alternating, and to adapt the pallet-box to such an arrangement. This system is followed by Messrs. Odell.

Further details connected with the tubular-pneumatic action will be found in the following Chapter and in certain subsequent Chapters devoted to pneumatic appliances and mechanism.

CHAPTER XXIX.

THE VENTIL WIND-CHEST.

— PNEUMATIC —

IN the preceding Chapter on the Tubular-Pneumatic Action we have described and illustrated certain slider and pallet wind-chests, in which the pallets are opened by means of pneumatic motors or levers, which form part of the construction or appointment of their pallet-boxes; these motors being actuated through the agency of the tubular-pneumatic system: and in Chapter XXVII. we have described and illustrated certain representative forms of ventil wind-chests, in which the actions are essentially mechanical. Such being the case, it is left for us to treat in the present Chapter of the higher and more recent developments of the ventil wind-chest, in which the motive power is derived either directly from the compressed air used for sounding the pipe-work, or from compressed air of a higher pressure alone or in coöperation with the pipe-wind.

By way of an introduction to the subject we may quote some pertinent remarks made by the celebrated German organ builders, Messrs. Walcker, of Ludwigsburg. Writing in the year 1893, they say:

"For a decade or so an essential change has been introduced by the foremost organ builders directing their efforts toward the abolishment of purely mechanical action and the substitution of pneumatic action. The latter recommended itself strongly; first, as a remedy for the many inevitable disturbances caused by the ever, and often very suddenly, changing humidity of the atmosphere; and, secondly, as it enabled couplings and combinations of all kinds to be effected with perfect ease, and without in any way interfering with the lightness of touch. The so-called tubular-pneumatic action (pneumatische Röhrentraktur) is the result of these efforts. As the wind-chest—the soul of the Organ as it were—is directly connected with the tubular-pneumatic action, it was of great importance for the organ builder to direct his attention above all to a proper association and adjustment of these two parts. Accordingly, a considerable number of pneumatic wind-chests have been invented, constructed on different systems, among which are those of our own introduction.

"In striving after the greatest possible simplicity, we hit, years ago, upon the membrane system with wind exhaust, in which the membrane embraces *at once part of the action and the pipe-valve.* We have constructed after this system large, three-manual instruments, with what were at the time *very satisfactory* results. A large, three-manual Organ built by us in 1888, with a membrane-chest and wind exhaust, is still partly provided with this feature.* However, having observed that this system had its drawbacks, we felt impelled to aim at a construction which would have the advantages of the pneumatic chest without its objectionable features, even though the greater simplicity of construction—otherwise valuable, to be sure—would have to be sacrificed. In our efforts, we, accordingly, returned to our old ventil wind-chest and essayed to provide it with pneumatic motors; namely, with small power-bellows similar in form to those used in Barker's well-known pneumatic action. These seemed to us to serve the purpose better, and to be more reliable and durable, than the membranes. The experiment was a success."

The simple pneumatic action which was applied to the old ventil wind-chest by Mr. Carl Walcker, in the year 1889, is shown in the accompanying illustration, Fig. CCVI. The wind-chest proper, of which only the valve portion is here indicated, is more fully shown in the first illustration (Fig. CLXXXV.) in Chapter XXVII.; and as its construction is fully described in connection with that illustration, it is unnecessary to allude to it here. A, Fig. CCVI., is a manual key, weighted at B, and furnished with a flat tail-spring C. D is a compressed-air chamber which extends the entire length of the manual clavier. Its bottom piece is bored vertically and horizontally opposite each manual key in the manner indicated; but we shall confine our description to the action belonging to a single key. The valve-throat passes through the bottom piece, its upper end opening into the compressed-air chamber D, while its lower end opens to the external air. This is covered and uncovered alternately by the small valves E and F. The horizontal duct G communicates with the valve-throat, and its outer end receives the pneumatic tube H, which is carried from the manual valve-box to the pneumatic action attached to the wind-chest. This latter action may now be described. I is a compressed-air chamber, which extends the entire length of the wind-chest, and is charged with the same wind that is furnished to the pipe-work planted on the wind-chest. For each note of the chest a valve-throat, J, is bored through the bottom piece of this chamber; and from this throat an air-channel is formed, as indicated at K. This air-channel is continued by the channel L, which extends transversely, in a channel-board, underneath all the stop-chambers of the chest. On the upper surface of this channel-board are fixed small motor-bellows, two of which are shown at M and N, the interiors of which communicate with the transverse channel L. The valve-throat J in the bottom of the compressed-air chamber I is furnished with the internal and external valves O and P, connected, as shown, by a common stem, on the lower end of which is screwed the small nut Q, faced with felt or leather. Underneath this nut is the small motor-bellows R, fixed to the tube-board S, and having its interior communicating with the air-channel T, into the outer end of which is fitted the upper end of the pneumatic tube H. The action throughout the appliance is extremely simple. On depressing the key A,

* The form of the chest here alluded to is shown in Fig. CCVII.

the tail-spring C presses up the external valve E and the internal valve F, closing the lower end of the valve-throat, and admitting the compressed air from the chamber D into the pneumatic tube H. The air in this tube is instantly condensed, inflating the motor R which raises the valves P and O. The external opening of the valve-throat J is closed by the valve P, and its internal opening, being freed from the valve O, allows the compressed air in the chamber I to rush into the transverse channels K and L. The air in the channel L instantly becomes

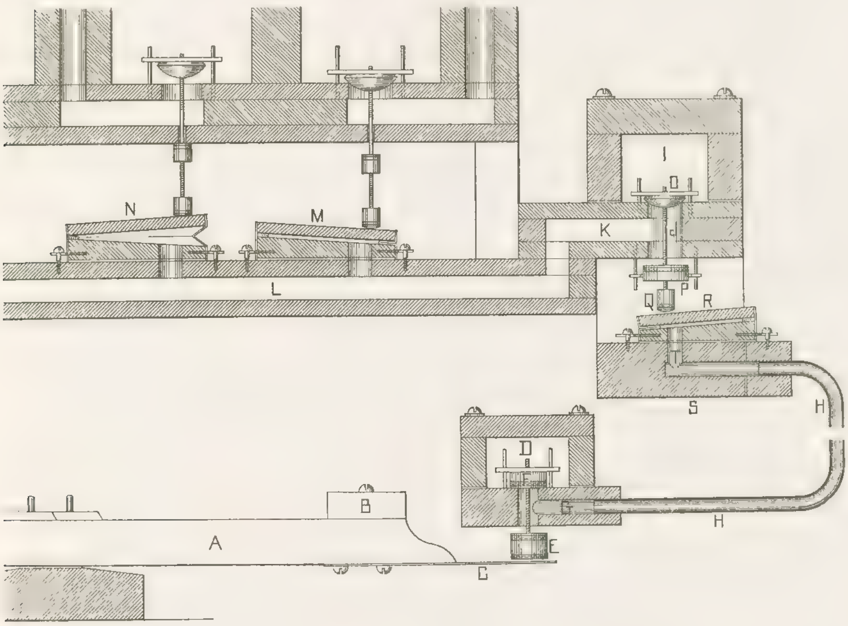


FIG. CCVI.

compressed and inflates the motor-bellows placed along it in the manner shown at N. These motors raise the valves in the stop-chambers of the wind-chest and admit the wind to the pipes. On releasing the key, the action is reversed, the compressed air in the channel L and the pneumatic tube H exhausts into the external atmosphere, and the motor-bellows collapse.

Speaking of the pneumatic action just described in comparison with their earlier membrane wind-chest, Messrs. Walcker remark:

"The principal reasons inducing us to abandon the somewhat simpler membrane-chest are the following: For the sake of the *greatest possible durability* we desired to abandon the light leather membranes with their twofold function—as action-members and pipe-valves—and to retain the cone-shaped valves, made of solid material, and tested during half a cen-

tury in more than six hundred of our modern instruments, operating them by means of little bellows constructed of wood and leather. The chest so modified has the advantage over the membrane-chest that there can be no wearing out of the pipe-valves employed, a process which must take place sooner or later with the leather membrane, which rests continually on the sharp edge of the pipe-hole while wind is in the Organ; and, furthermore, that the little bellows, on the outside of the chest, is put in operation, under pressure, only when the corresponding key is pressed down: whereas the membrane, within the chest, is under pressure from the first moment of blowing, and remains mostly under bilateral pressure while the blowing apparatus is in action, whether the Organ is played or not."

These remarks respecting the employment of membrane-chests are valuable, coming, as they do, from builders of so great experience. They enforce them further in the following remarks:

"Even if the membrane, as such, possessed the same durability as the little bellows, it could offer only a fraction of the resistance to wear presented by the bellows, because while the latter is brought into action only during the playing of the instrument, the membrane is constantly under the pressure of condensed air, involving a large amount of wear. The simplification of construction [in the membrane-chest] is accordingly attained only at the sacrifice of durability.

"Further reasons for the location of the action-member on the outside of the wind-chest are: First, the ease with which the little bellows is at all times reached in case of an accidental derangement—an advantage which is not possessed by the internally-located membrane; and, secondly, by the fact that the bellows, outside the chest, has the all-important advantage over the membrane inasmuch as in case of the action-member being damaged, or ceasing to be air-tight, the little bellows simply silences the single note to which it belongs, while in the case of the internally-located membrane, a rupture or displacement will allow the highly compressed air from the action-channel on which it is placed to rush into the stop-chamber and cause the entire stop to emit unwelcome sounds, even when the draw-stop ventil remains closed. It is easy to realize that a greater disturbance is caused in an Organ by the speaking of a pipe against the performer's wish, than when some single pipe remains silent for the time being." *

The above remarks will be better understood on the examination of the accompanying illustration, Fig. CCVII., which shows Transverse Sections of a portion of the Walcker membrane wind-chest, embracing the pneumatic action, and two stop-chambers differently fitted with membranes. As the lower key action is precisely the same as that shown in Fig. CCVI. it is not repeated in the present illustration. Its connection by means of the pneumatic tube H is, however, indicated. In the upper Section (1), A and B are two stop-chambers, into which compressed air is admitted from the draw-stop ventils. In the chamber A the lower part of the pipe-duct C is in the form of a tube, turned from beech or peartree, open at its lower end, and glued at its other end into the upper-board D, in which the pipe-duct is continued to where the pipe is planted.† Directly under

* These quotations are free translations from the leaflet on the "Walcker'sche Kegellade," issued by Messrs. E. F. Walcker & Co. in 1893. The illustration of the cone-chest, Fig. CCVI., is prepared from a drawing kindly furnished by the Company.

† Instead of separate tubes being employed, as described, the wind-ducts for the entire stop may be bored vertically through a longitudinal bar. The lower surface of the bar around the wind-ducts should be so treated as to allow the membranes to have a perfect contact; or turned rings of hardwood may be inserted in the ends of the ducts, projecting slightly to receive the membranes.

the tube the bottom piece is hollowed out, forming the air chamber E, and covered with the flexible membrane F, firmly glued around the edge, as indicated. This membrane is of soft and close-grained leather. The air chamber communicates with the pneumatic channel G through the hole I. The stop-chamber B is differently treated. Its bottom piece is pierced with the hole J, through which the compressed air passes on its way to the pipe-duct K. This pipe-duct is bored vertically in the longitudinal bar L, and is prolonged through the upper-board M to the pipe planted above. The membrane N is glued around its edges, so as to inclose both the hole J and the entrance to the pipe-duct K, but is left perfectly free between them. In this form of construction the auxiliary channel O is provided, which communicates with the main pneumatic channel G through the open-

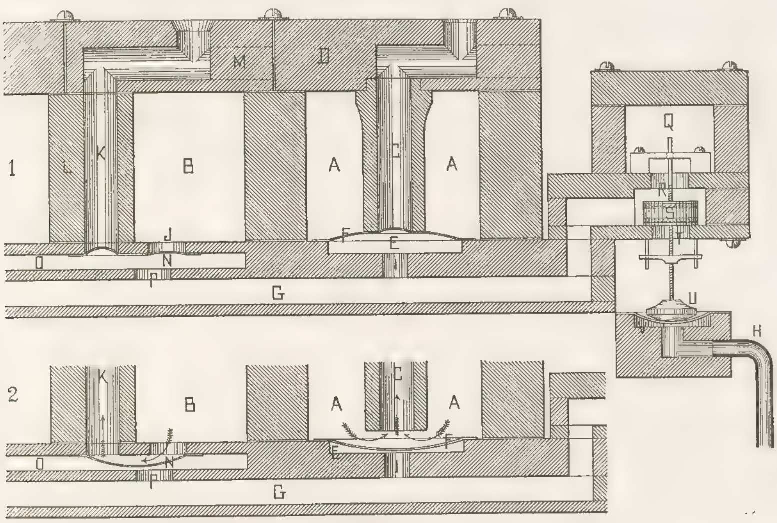


Fig. CCVII.

ing P. We have now to describe the part of the key action, placed alongside the wind-chest as shown in the upper Section (1). Q is a longitudinal chamber, charged with air at a higher degree of compression than that adopted for the air furnished to the stop-chambers A and B. This is necessary to support the membranes against the pressure of the pipe-wind in the stop-chambers, and to properly close the pipe-ducts which lead to the pipes, in the manner indicated in the upper Section (1). The opening R allows the compressed air in the chamber Q to pass into the pneumatic channel G, when the double-faced disc-valve S is in the position shown, covering the exhaust opening T. The stem of this valve is held in a vertical position by means of the small bridge above and the guide-

bar below, while its lower end is screwed into the turned hardwood button U, which rests on the upper surface of the leather puff V. This puff is inflated by high-pressure wind which is sent from the key valve-box through the pneumatic tube H. The action is represented at rest, or when the corresponding manual key is untouched. The highly compressed air, or action wind, from the chamber Q fills the pneumatic channels G and O, and presses the membranes F and N tightly against the pipe-ducts C and K and the opening J in the manner indicated. Accordingly, the lighter pipe-wind in the stop-chambers A and B cannot enter the pipe-ducts C and K. Now, the instant the manual key is depressed, compressed air rushes through the tube H and inflates the puff V, raising the valve S until its upper face covers the opening R. The compressed air in the channels G and O, aided by the pressure of the pipe-wind on the upper surface of the membranes F and N, instantly exhausts into the open air through the opening T. The membranes assume the positions shown in the lower Section (2), and the compressed air in the stop-chambers rushes into the pipe-ducts C and K in the directions indicated by the arrows. When the manual key is released, the compressed air in the puff and pneumatic tube exhausts itself through the key valve-box into the open air; the valve S falls into the position shown in the upper Section (1), and the high-pressure air in the chamber Q re-enters the pneumatic channels G and O and presses the membranes F and N against their respective pipe-ducts, silencing the pipes planted on them.

In the year 1886, Mr. Charles S. Haskell, of Philadelphia, Pa., took out a patent* for a membrane wind-chest very similar to, and somewhat simpler in construction than, the Walcker membrane-chest above described. A brief description of this wind-chest is all that is necessary here. In the preamble of the Patent Specification the inventor says:

"My invention relates in general to the wind-chests of pipe-organs, and relates specifically to the valves which control the escape of wind from out the wind-chambers of said wind-chest to the pipes, the improvement residing in a specific construction of valve, wind-chambers, and wind-chest. The object of my improvements is to dispense with the pneumatic bellows, and to render the construction of the wind-chest equally simple, less expensive, and more effective than when pneumatic bellows are employed."

In this wind-chest the longitudinal stop-chambers are formed in the usual way, having very thick bars between them, upper-boards on which the pipe-work is planted, and transverse channel-boards. The pipe-ducts are bored vertically through the bars, and close to the sides of the same. Where the pipe-ducts are bored the lower edges of the bars are beveled off, allowing the compressed air in the stop-chambers to pass into the pipe-ducts. A flat surface is left on the bars, between the bevels, to allow the transverse channel-boards to bed air-tight against the bars, and so effectually separate the stop-chambers. In the upper surface of the transverse channel-boards, and directly under the pipe-ducts, are formed small circular or oval sinkings, over which are glued the loose and flexible membranes

* United States Letters Patent, No, 337,326, dated March 2, 1886. Application dated July 24, 1884.

required to close or open the lower orifices of the ducts. These puffs communicate with their proper pneumatic channels, which open into the valve-throats, and through which they are charged with compressed air or are allowed to exhaust into the open air. The membrane-valves (or "diaphragm-valves," as they are designated in the Patent Specification) are formed of an air-tight and pliable material, and securely glued around the sinkings, while they are pressed down in the same to give them the necessary amount of play under the action of the condensed air. As the membranes have to be blown upward, against the resistance exercised by the pipe-wind in the stop-chambers, a wind of higher pressure has to be furnished to the pneumatic channels from the attendant valve-box. The action of this wind-chest is similar to that of the Walcker membrane-chest. When the manual keys remain untouched, all the pneumatic channels and the puffs are charged with the high-pressure air, and as all the pipe-ducts are closed by the membranes, no pipe can speak whether the stops are drawn or not. On the depression of a key, the high-pressure air is cut off from the corresponding pneumatic channel, while, at the same instant, the channel is opened to the external air. The membranes connected with this channel are blown down into their sinkings by the compressed air in the stop-chambers, and the compressed air rushes up the exposed pipe-ducts and gives voice to the pipes thereon. On the release of the key, the reverse action takes place, and the membranes close the pipe-ducts in the manner already described. We may add to this brief description the claims made by the inventor in his Specification:

"I claim—1. The combination, in a pipe-organ, of a pallet-box, a wind-chest provided with partition-bars containing pipe-ducts and beveled off as to their under surfaces, a bottom board for the wind-chest provided with valve-seats, orifices, and valve-ways and diaphragm-valves.

"2. The combination, in a pipe-organ, of a wind-chest provided with partition-bars which are beveled, as described, and which contain pipe-ducts opening upon the beveled surfaces, a bottom board containing valve-ways, orifices opening from said valve-ways [pneumatic channels] below the pipe-ducts of the partition-bars, valve-seats [sinkings] formed in connection with said orifices, and diaphragm-valves applied to said valve-seats and adapted to close either the pipe-ducts or the orifices of the valve-ways.

"It is proper for me to state, however, that diaphragm-valves as a mechanical contrivance for controlling the pipes of an Organ are not novel with me, and that to such a valve, broadly, I lay no claim."

In the year 1891, Mr. Carl Gottlieb Weigle, of Stuttgart, took out American Letters Patent* for a membrane wind-chest which is in all essential features identical with that invented by Messrs. Walcker years before, and introduced by them in certain large instruments, and notably in a three-manual Organ constructed in the year 1888. This so-called Weigle membrane wind-chest (Weigle'sche Membranlade), is also similar in general principle of construction and mode of action to the wind-chest patented by Haskell in 1886, and for which the Application was filed in 1884, seven years before Weigle secured his patent. In our opinion the

* United States Letters Patent, No. 457,686, dated August 11, 1891.

Weigle chest is inferior in certain respects to the Haskell chest. Of course Weigle was unable to obtain a patent in his own country; and it is very remarkable that, in face of the earlier patent granted to Haskell, he was able to secure patents in the United States and certain other countries. The question is: Are his patents, under these circumstances, of any value, granting that the appliance patented is to some small extent valuable?*

Of all the forms of the membrane wind-chest introduced up to the year 1896, with which we are acquainted, that invented by Mr. Philipp Wirsching, Organ Builder, of Salem, Ohio, is the most efficient and reliable. This wind-chest was patented in 1896.† In the preamble of his Specification the inventor says:

"My invention relates to pipe-organs, but has special reference to the wind-chest, constituting a most important feature thereof. The invention more generally stated resides in certain characteristic features of construction involved in wind-chest bars or partition-bars employed as side walls of the stop-channels; the combination therewith of flexible diaphragm-valves by means of which communication is established between the stop-channels and their respective musical pipes; diaphragm cases or pockets for inclosing said valves and communicating with exhaust-channels in the top-board; means whereby said stop-channels and exhaust-channels are placed in controllable communication with a wind-trunk or organ bellows common to both for supplying them with wind at a uniform rate of pressure, and in certain arrangements and combination of parts. . . .

"This being the nature of my invention, its object is the production of a wind-chest wherein the mechanical and pneumatic properties are designed and adapted to insure prompt, noiseless, and easy action of the parts with perfect accord and the least possible expenditure of power; a wind-chest composed of interchangeable parts adapted to be cheaply and accurately assembled by labor that may be comparatively unskilled; a wind-chest which is extremely simple in its construction, effective in its operation, and durable."

Nearly all the above claims are amply supported by the wind-chest as constructed and used by Mr. Wirsching. If it were not for the imperfection common to all the wind-chests in which membrane- or diaphragm-valves are used; namely, the liability of the membranes becoming stiff or otherwise imperfect in their operation through the injurious action of the ever-changing atmosphere, there could be no exception taken to the Wirsching membrane wind-chest. Apart from its comparatively simple construction, it has the great merit of being quickly and easily repaired without necessitating the removal of anything beyond the imperfect valve or valves: and as all valves are of definite sizes and interchangeable, and are located outside the stop-chambers, a few turns of a screw-driver is all that is required in removing an imperfect valve and adjusting a new one. We know of no wind-chest in which this process can be so readily performed. Apart from the

* Desiring to fall into no error in this matter, and to avoid any chance of appearing unjust, we communicated twice with Mr. Weigle respecting the membrane wind-chest and certain other inventions he lays claim to; but he has neither proved himself sufficiently business-like nor courteous to even acknowledge our letters. Probably, in this case, "silence is golden:" we certainly think it is. How different is the kind and courteous treatment we have experienced from Germany's most distinguished organ builders, Messrs. E. F. Walcker & Co., of Ludwigsburg.

† United States Letters Patent, No. 560,559, dated May 19, 1896. Application dated February 27, 1895.

tendency of the diaphragm-valves to become sluggish in their movements after long exposure, the chief objection that can be fairly advanced against this pneumatic wind-chest is that it, in common with all membrane-chests, requires two pressures of wind; one to force the membranes away from the orifices of the pipe-ducts and sound the pipe-work, and the other, of higher pressure, to force the membranes against the orifices of the pipe-ducts and silence the pipe-work.

The accompanying illustrations and the following brief description will thoroughly explain the construction of the Wirsching membrane wind-chest. Fig. CCVIII. is a Transverse Section through two stop-chambers, cutting through the center of two membrane-valves. The sides of two other valves are shown, because in the actual work the valves are disposed in zigzag fashion, the centers of those on one side of the stop-chamber falling midway between the centers of those on the opposite side. This disposition is dictated by the proper planting of the pipe-work in double ranks. C and D are two stop-chambers formed by the bars E, the pieces F, and the oil-cloth strips G. These chambers contain nothing but the

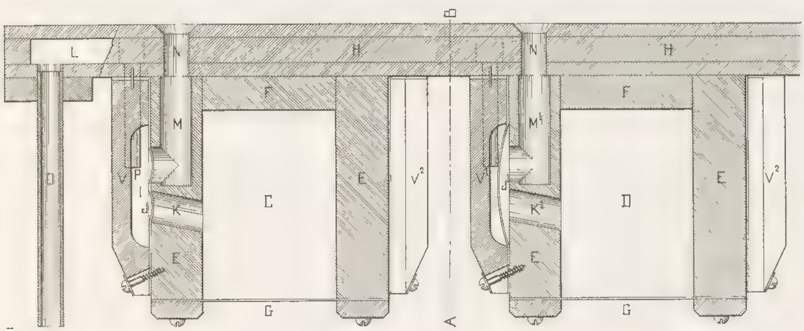


Fig. CCVIII.

compressed air furnished to them through the stop-ventils. Such being the case, the stop-chambers never require to be opened when once properly put together. H is the upper-board, formed of three layers of wood. The bottom and top layers have their grain running longitudinally, or lengthwise of the chest, while the middle layer has its grain running transversely. This middle layer is formed of numerous narrow boards, between which are left the pneumatic channels for the actuation of the membrane-valves, under the control of the manual key action, as usual in pneumatic, compartment wind-chests. Between these pneumatic channels are bored the pipe-ducts N, which continue the ducts M in the bars E. The relative positions of the transverse pneumatic channels and pipe-ducts are indicated in the Longitudinal Section, Fig. CCIX. The channels are shown at L, while the ducts are indicated by dotted lines. In Fig. CCVIII. the membrane-valves are shown, in section, at V and V^1; while the ducts which lead from the stop-chambers into them are shown at K and K^1. The valve-blocks are oblong pieces

of white pine, about 5¼ inches long, ⅞ inch thick, and of various widths according to the size of the stops and pipes they supply. Externally, their lower ends are splayed and forked to receive the binding screws—one only to each valve, as shown. Their upper ends are furnished with metal pins, which fit into holes in the upper-board, and hold them firmly in position against the bars. The inner faces of the blocks have the oval-shaped depressions I, and over all are secured the leather membranes J and J^1. To obtain the best results the inventor adopts the following method of applying the membranes: Instead of cutting the sheepskins lengthwise (from head to tail), as usual, he cuts them crosswise into strips of the widths required by the different blocks. The reason for so doing is that membranes of a maximum elasticity are obtained by this mode of cutting. The inventor lays considerable stress on this, saying: "It will be noticed that in lifting an animal by the skin the latter stretches considerably, which is not the case when one tries to stretch a skin lengthwise. In attaching the membranes to the blocks, the

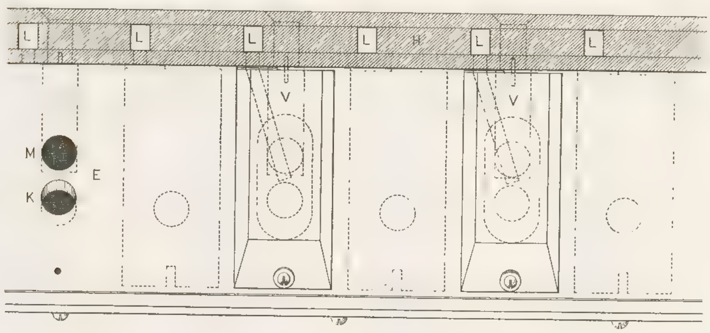


FIG. CCIX.

leather strips (unstretched) are laid on thick, soft felt, and the blocks, having their flat surfaces glued, are pressed upon them with sufficient force to cause the leather to expand somewhat into the recesses of the blocks." The inventor adds: "A membrane so treated will always work right; while, on the other hand, one having the grain of the leather running in the opposite direction, glued on tight, and subsequently rubbed into the recess, will never make a reliable or durable valve." It is just on such niceties as these that the perfection of organ mechanism depends. The necessary communication between the interior of the membrane-valve and the adjoining transverse pneumatic channel in the upper-board is obtained by a hole bored obliquely through the top of the valve-block into the oval depression behind the membrane. The entry of this hole is shown at P, in Fig. CCVIII., while its oblique direction, as it descends from the transverse pneumatic channel L, is indicated by dotted lines in Fig. CCIX. An end of a transverse pneumatic channel is shown, uncovered, at L in Fig. CCVIII. From this

descends the tube O, the lower end of which is connected with the secondary pneumatic of the attendant pneumatic station; and through which the membrane-valves are charged with highly-compressed air while the corresponding manual key remains untouched, and through which the valves exhaust into the external air when the key is depressed.

In Fig. CCIX. is given a Longitudinal Section of a small portion of the wind-chest now under consideration. The Section is cut (on the line A—B in Fig. CCVIII.) between two stop-chambers, showing the arrangement of the transverse pneumatic channels L in the upper-board H. At V are shown the backs of two of the membrane-valve blocks, while on each side of them are indicated, by dotted lines, the positions of the alternate valves, placed on the other side of the stop-chamber. At M and K are shown the two openings of the pipe-ducts into the membrane-valve, which latter is here omitted to display the ducts.

Referring again to Fig. CCVIII., we may briefly describe the manner in which the chest operates. On the left side of the stop-chamber C the membrane-valve J is shown pressed closely against the orifices of the pipe-ducts K and M, under the influence of the highly compressed air supplied from the pneumatic station, through the tube O, and the pneumatic channel L. As long as the membrane-valve remains in this position, no wind from the stop-chamber C can find its way to the pipe planted on the upper duct N. When the corresponding manual key is depressed, the tube O is opened to the external air, and all pressure is removed from the interior surface of the membrane-valve. The compressed air in the stop-chamber D instantly blows the membrane J^1 away from the ducts K^1 and M^1, as shown, and passes upward to the pipe planted over them. On the key being released, the high-pressure air again fills the interior of the valve-block, the membrane resumes the position shown at J, and the pipe is silenced. In the event of a valve going out of order through any cause, all that has to be done is to draw the single screw, remove the valve-block, slip a new one into its place, and restore the screw,—the work of two or three minutes,—which can be done while the Organ is being used. The high-pressure air used for closing the membrane-valves need not be more than 1½ inches above the pressure of the pipe-wind. The ventils for supplying the compressed air to the stop-chambers may be located in any convenient position, preferably in the center of the wind-chests. These ventils are operated by pneumatic valves commanded by the draw-stop action in the usual manner.

Membrane wind-chests, constructed after the fashion of those above described, are, in our opinion, not to be recommended. Not only are they open to the serious disadvantages clearly detailed by Messrs. Walcker, but to others equally obvious. They are very unreliable and subject to derangement in a climate subject to extremes of humidity and drought. Unless their stop-chambers are made unusually large, and are copiously supplied with wind, there will be a pronounced unsteadiness in the speech of the pipe-work, especially in rapid *staccato* and full chord playing. But as the membrane wind-chests above described can be cheaply made, it is probable that one form or another will have a certain support where the saving of money is the all-important consideration.

In the year 1887, Charles Brindley, Organ Builder, of Sheffield, took out a patent in England for a practically complete tubular-pneumatic action and pneumatic wind-chest.* The wind-chest, in all its essential features, closely resembles the Walcker wind-chest previously described and illustrated (Fig. CCVI.). The chief difference obtains in the manner in which the motor-bellows are adjusted to the pipe-valves. While in the Walcker chest each pipe-valve is actuated by a separate motor-bellows, in the Brindley wind-chest all the pipe-valves belonging to the same note are raised by a transverse bar, which is carried on the top-boards of a series of small, square, parallel-acting, motor-bellows. This appliance is described in the Patent Specification thus: "The pneumatic motor lift consists of a bar placed under the projecting lower ends of the spindles or rods of the channel-valves [pipe-valves], and is raised by means of a series of small bellows; the bar in rising, comes in contact with and lifts the channel-valves," thereby admitting air from the stop-chambers to the pipe-ducts. This action cannot be recommended.

In the year 1885, Hilborne L. Roosevelt, of New York, N. Y., and Charles S. Haskell, of Philadelphia, Pa., took out Letters Patent for a pneumatic ventil wind-chest,† which was a decided improvement on an earlier form used by Mr. Roosevelt. This earlier form is mentioned in "Appleton's Cyclopædia of Applied Mechanics" (1879) thus: "This wind-chest resembles Walcker's in having the air chambers running longitudinally, but the valves are differently placed. The object in this construction is to substitute compressed air for the mechanism used by Walcker [See Fig. CCVI.], thereby gaining lightness of touch, accessibility to the valves from below by simply removing the bottom boards, non-liability to derangement from atmospheric changes, no parts to be regulated, and no buttons to slip; the positive motion of the bellows thus insuring a full supply of wind to the pipes." We may properly illustrate and describe this tentative construction before entering on that covered by the patent above mentioned. A Transverse Section of portion of the wind-chest is given in Fig. CCX. A and B are longitudinal stop-chambers, charged with compressed air from the draw-stop ventils. These chambers are formed by the longitudinal bars C, the upper-boards D, and transverse channel-boards E. F and G are the pipe-ducts leading from the stop-chambers to the pipes planted on the upper-board. The pipe-ducts have their lower orifices furnished with the pallets H and I, which are closed by the wire-springs J. Directly opposite these pallets, and connected with them by the wire links K, are the small bellows L and M, the interiors of which communicate with the pneumatic channel N by the ducts O and P. The channel N opens into the valve-throat Q, the upper and lower orifices of which are alternately opened and closed by the disc-valves R and S. T is the longitudinal valve-box, charged with air of the same pressure as that supplied to the stop-chambers. The disc-valves R and S are carried on the vertical stem U, the upper end of which passes through the guide-board V, while its lower end is supported, by a cloth and button, on the small lever W. This lever, acted upon by the strong steel spring X, holds the

* English Letters Patent, No. 12,211, dated September 25, 1887. Application dated September 25, 1886.

† United States Letters Patent, No. 323,829, dated August 4, 1885. Application dated July 24, 1884.

lower disc-valve tightly against the valve-throat Q, in the position indicated. Y is the pull-down connected with the key action, by means of which the lever W is drawn down, reversing the position of the disc-valves, which fall of their own weight, aided somewhat by the pressure of the condensed air in the chamber T. The operation of this wind-chest may be briefly described as follows: The positions of the disc-valves and the bellows and pipe-pallet in the stop-chamber A are those which obtain while the manual key remains untouched. The compressed air from the chamber T fills the interior of the bellows L, and, as a state of equilibrium is instituted, the spring J closes the pallet H and expands the bellows, as indicated. When the stop-chamber A is not charged with compressed air the positions of the bellows L and the pallet H remain as shown, and are unaffected

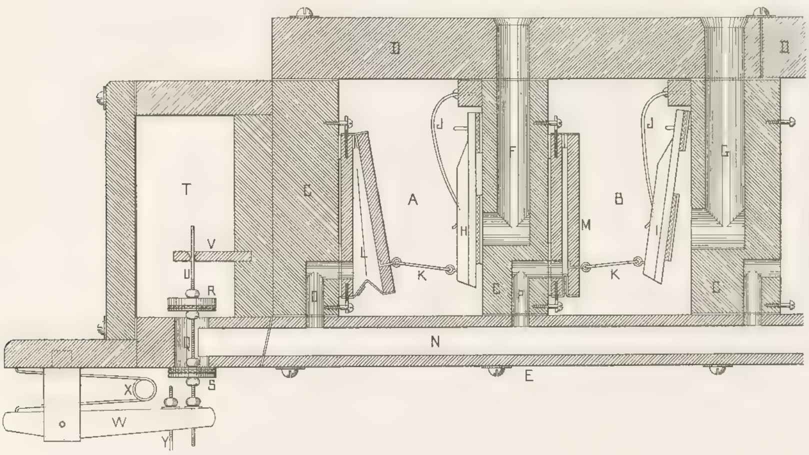


Fig. CCX.

by the key action. Now, when the manual key is depressed, the lever W is pulled down by the wire Y, and the disc-valves R and S fall; the former cutting off the compressed air in the chamber T from the pneumatic channel N, and the latter valve opening the throat Q to the external air. The compressed air in the channel N and the bellows L instantly exhausts, and the compressed air in the stop-chamber A closes the bellows linked to the pallet, and then rushes into the pipe-duct F, causing the pipe planted thereon to speak. The positions of the bellows and pallet, while the key is held down and the pipe is speaking, are shown at M and I in the stop-chamber B. The bellows have twice the area of surface that the pallets have, and are, accordingly, under the action of the compressed air in the stop-chambers, strong enough to overcome the pressure on the pallets and the power exercised by the springs J. When the manual key is released, the mechanism instantly returns to the condition shown in the chambers A and T.

We may now enter on the description of the wind-chest patented by Messrs. Roosevelt and Haskell in the year 1885. While this chest is constructed on the same general principle as that just described, it differs materially from it in the appointment of the stop-chambers. This appointment is characterized by extreme simplicity and comparative fewness of parts. By way of an introduction to our description we give the following quotation from the preamble of the Patent Specification :

"The objects of our improvements, which relate to the pneumatic bellows of the wind-chest, and utilize compressed air in lieu of the usually complicated pneumatic levers, touch-lighteners, and kindred mechanical contrivances, are to simplify construction, obviate the necessity of dependent mechanism, render the expansion and contraction of the material used in the manufacture of the wind-chest a matter of no consequence, overcome such objections as have heretofore been inseparable from inflation, render the action more rapid and attended with less noise, and relieve weight of touch.

" Heretofore in pipe-organs, pneumatic bellows placed in the wind-chest have been, in various modes of application, employed to control the throats or orifices of the wind-ducts leading from out the chambers of the wind-chest to the pipes or to the atmosphere. Thus, for instance, the movable board of the pneumatic bellows itself has been so relatively disposed with respect to the pipe wind-duct as to itself constitute a valve to the throat of said duct when the bellows has been expanded, the said movable board having been retained in its expanded position by the assistance of a spring interposed between the fixed and movable boards. Thus, also, a spring-controlled pallet over the pipe-throat has been linked to the movable board of a pneumatic bellows so as to be controlled by the movement of said board. Thus, again, in mechanical musical reed-instruments of the character operating through the medium of a perforated strip of sheet-music, the movable side of a device of somewhat the character of a pneumatic bellows has been prolonged and linked to a pivotal valve controling the air-duct. At the out-start, therefore, we desire to disclaim either the invention of a pneumatic bellows as such, its application within a wind-chest, or its utilization within said wind-chest as a device, broadly as such, for controlling the throat of the wind-duct leading to the pipe, that which, in fact, constitutes our invention being such a specific improvement in the construction and application of the pneumatic bellows."

We may first describe and illustrate this pneumatic bellows and its allied parts, embodying the improvements covered by the patent above quoted from. In Fig. CCXI. are given Front and Side Views and a Longitudinal Section of the pneumatic bellows detached from the wind-chest. The drawings, taken from an actual bellows, are made to scale. In the highest octave or so of the wind-chest the bellows are narrower and longer, so as to lie within the limited space in that portion. For notes below the middle octave, the bellows are increased in width sufficiently to lift the larger disc-valves required for the tenor and bass pipes. Varied sizes of bellows are, of course, used for the stops of different kinds and pitches. The bellows is formed, in the manner indicated in the Section (3), of the two small boards A and B, chamfered and slightly rounded on the inner edges of their sides and free ends, hinged together at their unchamfered ends, and leathered with sumac-tanned skiver of medium thickness and great pliability. The hinged ends are kept a sufficient distance apart, to permit the leather to fold properly, by small strips of felt, shown at C ; while a piece of soft, springy felt is glued to the face of the end fold at D to prevent noise and an excessive wear in the leather

folds. The hole E is bored in the stationary board A for communication with the duct in the bar and the corresponding pneumatic channel of the wind-chest. Into the ends of this board are driven the small forked cleats of tinned iron F and G, by means of which and two small screws the bellows is readily fixed to the side of the wind-chest bar H. In a small groove in the face of this board is fixed the hard brass wire spring I. Into the hinged end of the movable board B is driven the valve arm J, formed of tinned iron, and bent to the necessary shape to hold the disc-valve K in proper position against the pipe-duct O. This arm has its end formed as shown in the Front View (2), having the small turned-up horn L on one side to engage the free end of the spring I. The disc-valve K is formed of hard millboard faced with fine felt and soft pallet-leather. It is secured to the arm

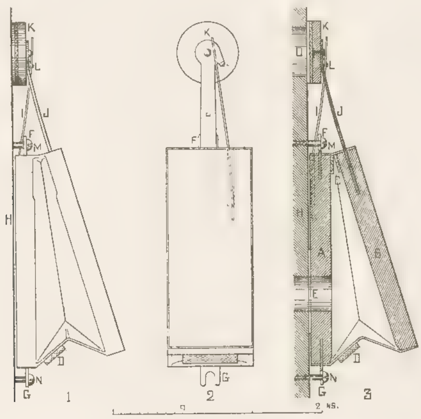


FIG. CCXI.

by a small rivet which permits it to move slightly so as to bed properly on its seat. To secure the bellows in its place in the stop-chamber, its upper cleat F is forked on the screw M, previously driven into the bar H; and the screw N is passed through the cleat G and driven into the bar until the bellows is pressed tightly against the bar. An air-tight contact is secured by the ring of soft leather glued to the bellows, around the hole E, as indicated.

Having described the form and construction of the pneumatic bellows and pipe-valve, we may now direct attention to their disposition in the "Roosevelt wind-chest." Fig. CCXII. is a Transverse Section of the key action side of this wind-chest, cutting through several of the stop-chambers and the key action valve-box, and showing the disposition of the draw-stop ventils which admit the compressed air into the stop-chambers. The compartments marked A, B, and C are the stop-chambers, charged with compressed air from the draw-stop ventils. An open ventil is shown, in cross section, at D, and a closed one at G. The longitudinal bars of the wind-chest are shown, in cross section, at H, against which are

screwed the pneumatic bellows E and F. Those at E are longitudinal sections, while side views are given of three bellows at F. The pipe wind-ducts, controlled by the disc-valves of the pneumatic bellows, are indicated at I; and these ducts are carried through the upper-boards J to receive the pipes of single-rank stops and a MIXTURE of III. ranks. Below the bars is a longitudinal section of one of the channel-boards, showing one of the pneumatic channels, K, from which the smaller channels L lead upward into the pneumatic bellows. The pneumatic channel K opens at one end into the vertical, circular valve-throat M, the upper end of which opens into the compressed-air chamber of the valve-box N, while its lower end communicates with the external air. This valve-throat is alternately covered and uncovered by the coupled disc-valves O and P. These valves are mounted, and operated by the key action, as previously described in connection with the earlier form of the Roosevelt wind-chest. The drawing, generally, shows the positions of the disc-valves and the pneumatic bellows while the corresponding manual key remains untouched. The compressed air from the valve-box N fills the channels K and L and the bellows E; and, as this air is of the same pressure as that furnished to the stop-chambers A and B, a perfect equilibrium obtains and no movement takes place. When the manual key is depressed, the tracker Q draws down the rocking lever R, and allows the disc-valves O and P to reverse their positions: at this stage, the condensed air from the chamber N is cut off, while that in the channels K and L and inside the pneumatic bellows E is allowed to exhaust into the external air. Instantly the compressed air in the charged stop-chambers closes the pneumatic bellows, and opens the pipe-valves and gives the pipes speech. In the stop-chambers in which there is no compressed air, the pneumatic bellows remain inactive under the pressure of their respective springs, as previously described. The bellows F in the stop-chamber B is shown collapsed and its pipe-valve moved away from its seat, allowing the compressed air in the chamber to enter the pipe-duct which is indicated in the bar and upper-board by dotted lines. At S is shown a Longitudinal Section of part of the draw-stop ventil-box. The ventils D and G, which are in the form of long pallets, are linked to the pneumatic power-bellows T and U, which have a much larger surface for the compressed air to act upon than their associated ventils. These power-bellows are operated by double disc-valves and pneumatic channels in precisely the same manner as the pipe pneumatics are actuated. The external parts of the draw-stop action are shown at V, while its other portions are indicated in Fig. CCXIII. In Fig. CCXII. is shown the exterior of the draw-stop ventil-box with its movable front board and one of its steel fixing bars. One draw-stop ventil is sufficient to supply such small chambers as are indicated at A and C: but for the supply of compressed air to the large chamber B—suitable for a stop of 16 ft. pitch—two ventils would be required, linked to a single large power-bellows; the linking being so arranged that one ventil would be opened slightly in advance of the other, materially assisting the action of the mechanism. The long wires W extend from the ventils through the wind-chest and carry the escape-valves X. These valves are for the purpose of instantly relieving the stop-chambers of their compressed air as the ventils close. When a draw-stop ventil is opened the corresponding escape-valve

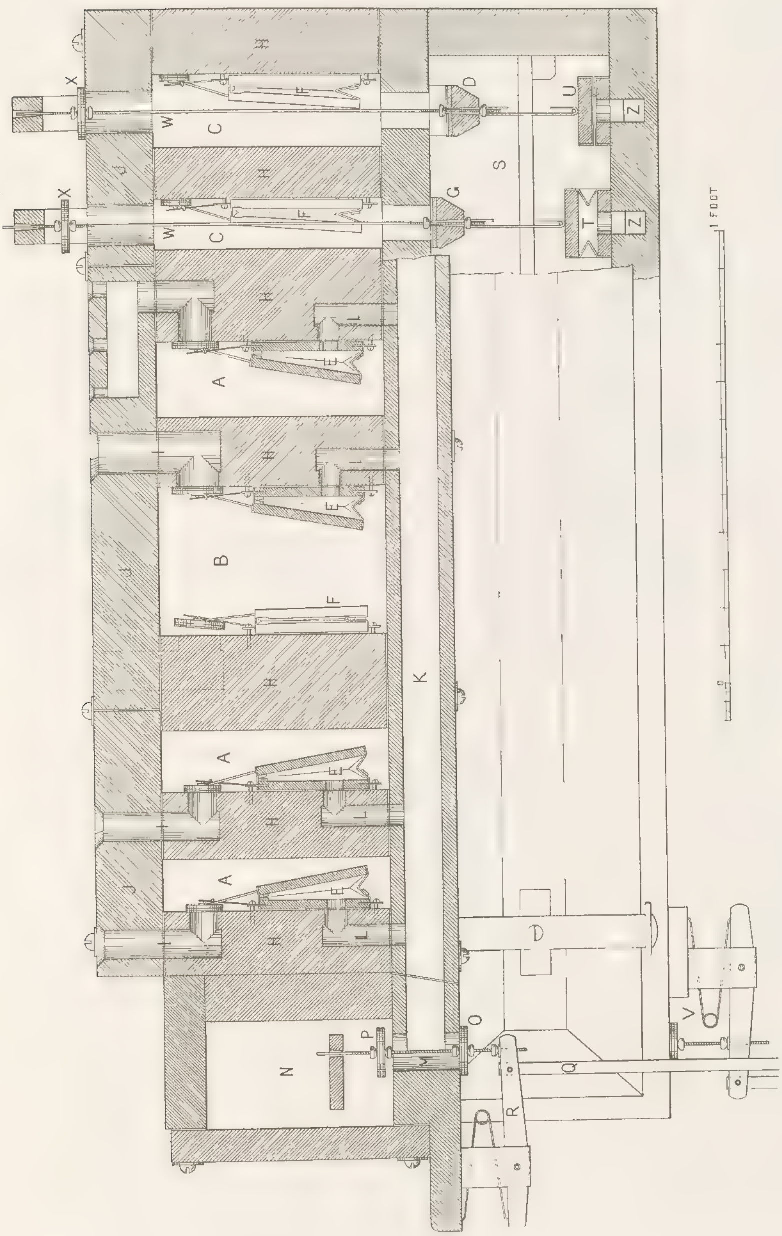


Fig. CCXII.

closes the orifice of the stop-chamber. This condition is indicated in connection with the open ventil D.

Fig. CCXIII. is a Longitudinal Section through portion of one of the stop-chambers of the Roosevelt-Haskell wind-chest, including a Transverse Section of the draw-stop ventil-box. The several parts shown in this illustration are lettered in the same manner as the corresponding parts in the Transverse Section, Fig. CCXII., so that the illustrations may be conveniently consulted together. The wind-chest here illustrated is in two divisions, having the pipes in each division planted tonally, the higher notes being toward the center. The stop-chamber A extends uninterrupted throughout the length of the wind-chest. Underneath the central portion of the chest extends, in a transverse direction, the draw-stop ventil-box, S. In this are shown longitudinal sections of the power-bellows T and the ventil G. The latter is held in position, with respect to the ventil opening, by the strong pallet-spring Y. The pneumatic channel which communicates with the interior of the power-bellows, and extends to the throat of the draw-stop disc-valves (indicated by dotted lines) is shown at Z. The manner in which the pipe pneumatic bellows are arranged, side by side, on the wind-chest bar is shown at E and F. The channel-boards, in which the pneumatic channels K are grooved, are each formed of two layers of clean white pine; the channels being cut in the upper and thicker layer, and then covered by the lower and thinner layer, securely glued on. These channel-boards lie across the chest, and are made in moderate widths, so as to be easily removed in the event of any valve going out of order. One board containing eleven pneumatic channels, is shown on the left of the ventil-box. All the movable boards in the construction of the wind-chest are put together with leathered joints, as indicated. As both the illustrations of this important wind-chest have been accurately reproduced from full-size drawings furnished us by the late Mr. Roosevelt, further description is unnecessary.

The only reasonable objection that can be urged against a wind-chest constructed on this system is that it consumes a large amount of wind even when no stop is drawn. Much wind unquestionably forces its way through the thin leather of the numerous pneumatic bellows into the uncharged stop-chambers, and thence through the escape vents, to the open air. And when it is remembered that in a small wind-chest of only six stops there are about three hundred and sixty-six pneumatic bellows, each of which has, on an average, about four square inches of exposed leather, one can form some idea of the wind being wasted while the pneumatic bellows remain inactive in the uncharged stop-chambers.

In the year 1886, Hilborne L. Roosevelt and Charles S. Haskell patented an ingenious wind-chest pneumatic action which in detail differs somewhat from that just described. From the construction of the pipe-valve pneumatic bellows, protected by this second patent,* it would seem that the inventors aimed at two important things; namely, to reduce to a minimum the waste of compressed air, and to materially simplify the draw-stop action connected directly with the wind-chest. In the accompanying illustration, Fig. CCXIV., is given a Transverse Section of

* United States Letters Patent, No. 336,351, dated February 16, 1886.

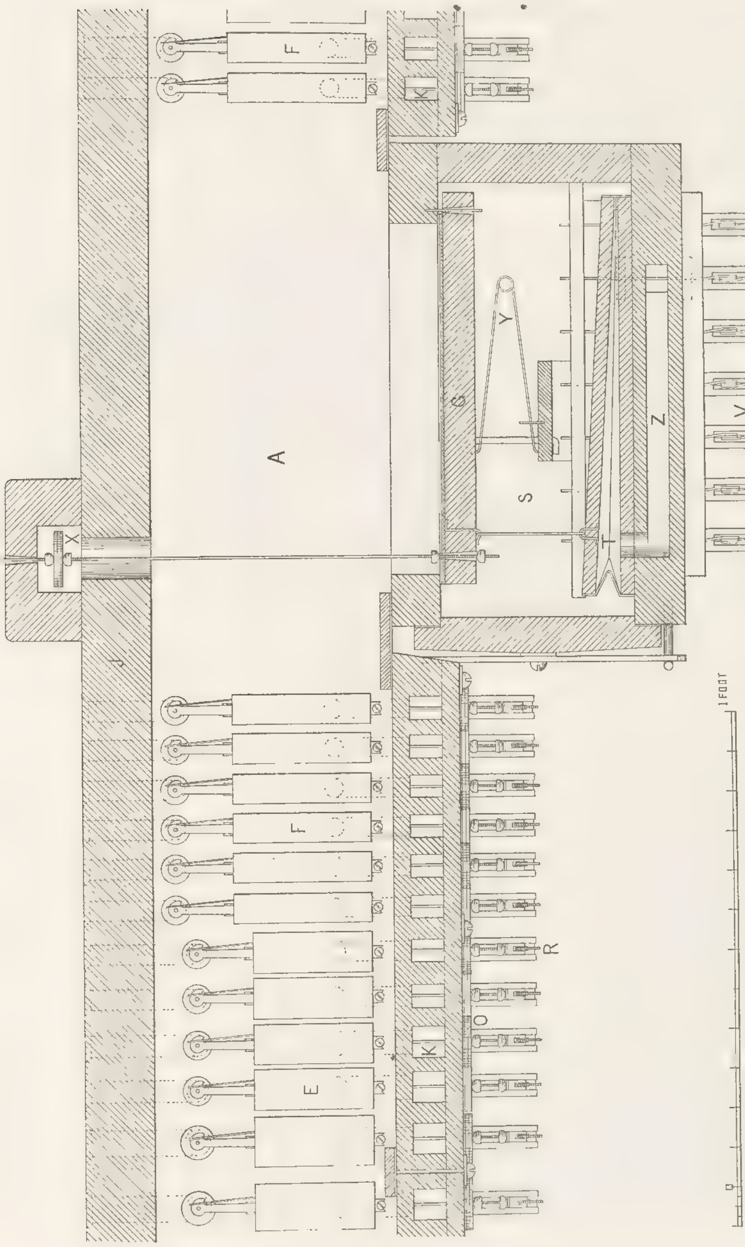


FIG. CCXIII.

two stop-chambers and the key action valve-box of the wind-chest now under consideration. It will be observed that the general construction of the valve-box A and the channel-board B, and the disposition of the longitudinal bars E, are similar to the construction and disposition of the corresponding parts described in connection with the preceding wind-chest. But instead of the pipe wind-ducts D being, as in the other wind-chest, bored through the upper-board C directly into the longitudinal bars E, they are carried through the longitudinal pieces F, glued to the

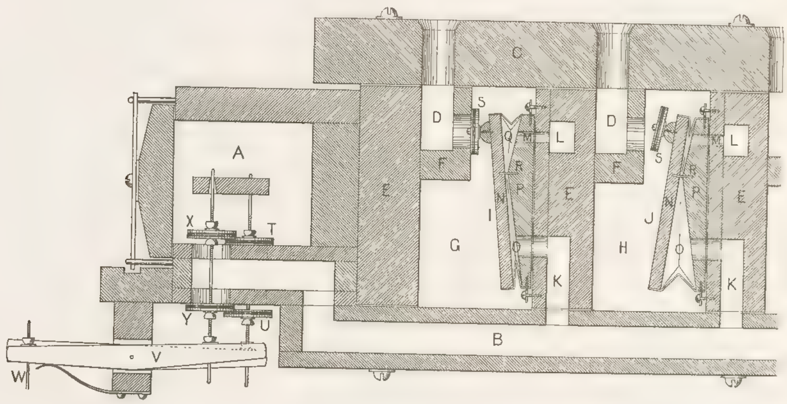


Fig. CCXIV.

sides of the bars. G and H are stop-chambers, which are directly charged with compressed air from the main wind-trunk all the time the Organ is being played. That is, they are not supplied from draw-stop ventils. Accordingly, if it is desired to shut off the compressed air from the entire series of stop-chambers, it must be done by a general ventil placed in the wind-trunk,—known as the "wind-trunk ventil,"—commanded by a special draw-knob or foot-lever. The bars E, against which the pneumatic bellows I and J are fixed, are grooved with the ducts K, which lead from the pneumatic channel B into the lower division O of the pneumatic bellows. In the higher part of the bars are formed the longitudinal channels L, which extend the entire length of the bars, and open into the throats of the valves of the draw-stop action, placed outside the wind-chest, at one of its ends. These channels communicate with the upper and smaller division Q of the bellows through the holes M. We now come to the description of the pneumatic bellows, which differs in form materially from that belonging to the preceding patent. We may use the language of the Patent Specification: P is the fixed board and N the movable board of the pneumatic bellows. The fixed board is conveniently provided with two oppositely or reversely inclined planes or surfaces, as indicated ; one of these surfaces, or that forming an inner side of the larger compartment O, being,

for instance, of twice the length of that surface which forms one of the inner sides of the smaller compartment Q. The movable board is hinged to the fixed board at R, or upon the line of junction of the inclined planes. Bellows-flaps of suitable proportions, arranged upon each side of the hinge of the boards, form two compartments, already designated as the larger and smaller, and complete the construction of what constitutes a double or compound bellows, having two compartments of different areas. The two perforations in the fixed board of the bellows, leading, respectively, in the completed instrument, into the larger and smaller compartments of the bellows, place the latter, when applied within the wind-chest, in communication, as to its larger compartment, with the pneumatic channel B, and, in the case of the smaller compartment, with the longitudinal channel L, which extends from the draw-stop valves. It is obvious, therefore, that compressed air admitted from the valve-box A will fill the larger compartment of the bellows, as at O in the stop-chamber H, while compressed air from the channel L will fill the smaller compartment, as at Q. It is to be understood that the hinge R prevents any communication between the two compartments of the bellows.

Securely connected with the upper portion of the outside face of the movable board of the bellows, or that outside the smaller compartment, is the disc-valve S, formed of stout millboard faced with fine felt and pallet-leather. This valve is so supported as to have a slight play, to render its perfect contact with its seat a certainty at all times. This disc-valve closes the internal opening of the pipe wind-duct D, in the manner indicated in the stop-chamber G; and retires from it, in the manner indicated in the stop-chamber H. To understand the operation of the pneumatic apparatus, it must be known that the longitudinal channel L is connected with a compressed-air box, fitted with double disc-valves, in all essentials similar to the key action valve-box A. By means of the double, or linked, disc-valves the channel L can be charged with compressed air, or opened to the external atmosphere, at pleasure. When the stop is drawn, the channel is placed in communication with the external atmosphere; and when the stop is silenced the channel is charged with compressed air. On the other hand, when the manual key remains untouched, the disc-valves connected with it remain in the positions indicated at T and U, placing the pneumatic channel B and the duct K in communication with the external atmosphere. Accordingly, as long as the key remains untouched, and whether the stop be drawn or not, the pneumatic bellows, within the stop-chamber, remains in the position shown at I in the chamber G, the condensed air in the said chamber closing the larger compartment O of the bellows, and pressing the valve S firmly over the entrance to the pipe-duct D. Now, when the key is depressed by the finger, the rocking lever V is moved by the pull-down W, and the disc-valves connected with it are raised to the positions indicated at X, Y, admitting the compressed air in the box A to the pneumatic channel B, and thence to the lower compartments of the bellows, through the ducts K. As the air both inside and outside the compartment O of the bellows is of the same pressure, no action takes place as long as the stop is not drawn, the smaller compartment Q being filled with compressed air of higher pressure than that in the stop-chamber G. But when the stop is drawn and the smaller compartment Q is

placed, through the channel L, in communication with the external atmosphere, the condensed air in the stop-chamber immediately, on the depression of the manual key, presses on the upper portion of the movable board N, and collapses the smaller division of the bellows, drawing the valve S away from the entrance to the pipe-duct D, as indicated by the bellows J in the stop-chamber H. Finally when the key is released, the larger compartment O of the bellows exhausts into the external atmosphere through the channel B, and the compressed air within the stop-chamber instantly collapses the larger compartment, and returns the bellows and its pipe-valve to the positions shown in the stop-chamber G.

Several organ builders have used modifications of the wind-chest as described in the Roosevelt-Haskell patent, dated August 4, 1885, and illustrated in Figs. CCXII. and CCXIII., but in all cases the principles involved are the same. Improvements have been made in the motors carrying the pipe disc-valves. The motors are reduced to the smallest dimensions practicable; and, to prevent loss of wind, are sometimes closed with a fine textile coated with India-rubber, instead of

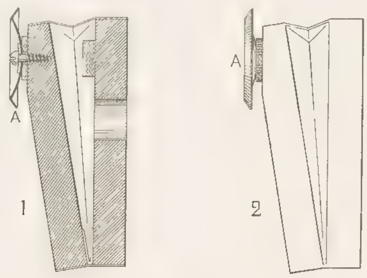


Fig. CCXV.

the skiver used in the Roosevelt pneumatic valves, through which a considerable amount of wind escaped. The disc-valves have also been improved, as in the wind-chests constructed by the W. W. Kimball Company, of Chicago. In these the disc-valves are solid, and bed upon soft leather glued to the surface of the bars. This Company has recently invented a new form of disc-valve, which appears to possess decided advantages over the ordinary flat forms. It is cut from thin sheet metal, and stamped into the shape indicated at A in the accompanying illustration, Fig. CCXV. The rounded rim of the disc-valve beds closely on the soft leather seat provided for it on the surface of the wind-chest bar in which the corresponding pipe-duct is bored. If these disc-valves are formed of tinned or nickel-plated copper, or, better still, of aluminium, and the leather used for their seats is free from any corroding substance, most satisfactory results are likely to attend their use. The metal valves have a slight play on their center-pins, so as to secure perfect contact at all times. Great care will be necessary, when an imperfect motor bellows is replaced by a new one, to see that the rim of its disc-valve fits accurately into the indentation made in the old leather seat.

In the year 1892, Frederick W. Hedgeland, of Chicago, Ill., took out patents* for a simple form of pneumatic wind-chest. In the preamble of the earlier Patent Specification the inventor says:

"My object in this invention is to greatly simplify the construction of this class of actions, and also to obtain better results in the matter of quick speaking by the pipes than have been heretofore secured.

"In practicing the invention, I employ small bellows for the purpose of opening and closing the valves connecting the pipes with the wind-chest, and maintain a pressure in such bellows greater than that in the wind-chest, so that the valve is opened whenever the pressure in the bellows is reduced below that in the wind-chest, and closed the instant the pressure in the bellows is again brought above that in the wind-chest.

"One of the leading features of my invention relates to the means employed for creating the unequal pressure in the valve-bellows and wind-chest; and it consists in the combination, with the Organ having the pneumatic action, of a double bellows, or, in other words, two bellows, one inside of the other; the inner one receiving the air from the feeders, and, when it is filled, venting into the outer bellows. The pressure is greater in the inner bellows, and a pipe connects this bellows with the series of valve-operating bellows, while the outer or larger bellows, in which the pressure is less, is connected by a pipe with the wind-chest."

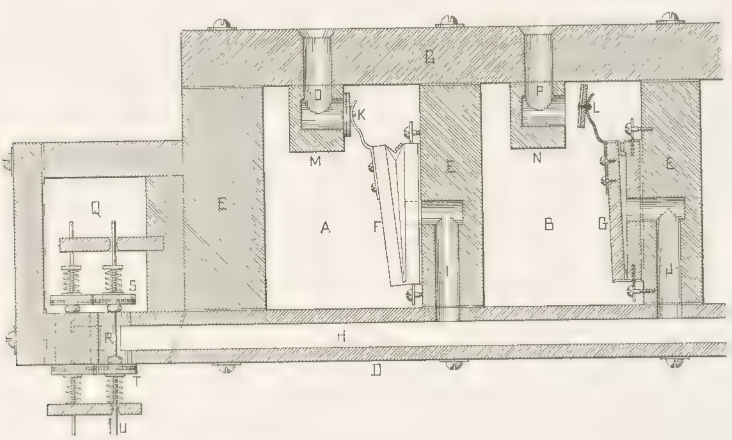


FIG. CCXVI.

The construction of the wind-chest covered by the Hedgeland patents will be readily understood from the following description and an examination of the Transverse Section of the chest given in Fig. CCXVI. A and B are two stop-chambers, formed, in the usual manner, by the upper-board C, the channel-boards D, and the longitudinal bars E. These chambers are supplied with compressed air, suitable

* United States Letters Patent, No. 476,796, dated June 14, 1892; and No. 488,607, dated Dec. 27, 1892.

for the pipe-work, from the draw-stop ventils situated at one end of the wind-chest. F and G are the valve-bellows, the interiors of which are in communication with the pneumatic channel H by means of the small channels I and J. The bellows carry, at the end of metal arms, the disc-valves K and L. Along the stop-chambers, and attached to the upper-board, are the longitudinal valve-bars M and N, in which the lower parts of the pipe-ducts O and P are bored, as indicated. Against the horizontal ends of these ducts the disc-valves bed, as shown at K. Q is the longitudinal valve-box, charged with air at a higher pressure than that in the stop-chambers. The valve-throat R places the transverse pneumatic channel H in communication with both the interior of the valve-box and the external air. The disc-valves S and T cover and uncover the orifices of the valve-throat R, in the manner already described in connection with the Roosevelt-Haskell wind-chests. It will be observed that small spiral springs are associated with the disc-valves in this wind-chest. These are for the purpose of regulating the play of the valves without regard to the motion imparted by the key action to the valve-stem U. The convenience of this practical arrangement can readily be realized. The pneumatic action of this wind-chest is as follows: When the disc-valves R and S are in the positions shown in the Section, the high-pressure air from the valve-box Q passes into the channels H and I, and inflates the bellows F, as shown. While in this state, the disc-valve K is held tightly against its seat; and the condensed air in the stop-chamber A is shut off from the pipe-duct O. When, by the key action, the valve-stem U is drawn down, and the positions of the disc-valves are reversed, the channels H and J are placed in communication with the external air. The condensed air in the stop-chamber B immediately collapses the bellows G, removing the valve L from the pipe-duct P, and allowing the pipe planted on it to speak. It is understood that no action takes place in the stop-chambers into which there is no condensed air or organ-wind admitted by the draw-stop ventils.

One other pneumatic wind-chest may be described in which small bellows are employed to operate the pipe-valves. The form alluded to is that patented by Philipp Wirsching, Organ Builder, of Salem, Ohio.* In the preamble of his Specification, the inventor says:

> "My invention relates to certain new and useful improvements in pipe-organs, and has for its object the construction of an instrument wherein the mechanical devices, their adjustment, the workmanship, and material are all designed, arranged, and adapted to insure prompt, noiseless, and easy action of the parts, with perfect accord and a harmonious voicing of the pipes.
>
> "To these ends, my invention consists particularly in a weighted, gravitating pneumatic, located within a wind-chest and suspended from the top thereof; also in a tri-part sound- or pipe-board, having formed therein exhaust-channels, each provided with a series of enlargements or pockets in direct communication with the interior of said pneumatics."

The chief peculiarity of this wind-chest obtains in the horizontal attachment of the pneumatic motors or valve-bellows to the under side of the upper-board, while the pipe-valves, fixed to them, close the pipe-ducts vertically. It is always desirable

* United States Letters Patent, No. 518,980, dated May 1, 1894. Application dated August 21, 1893.

that the pipe-valves bed vertically, because in that position they readily clear themselves of anything that may fall down the pipe-ducts and temporarily lodge upon their leather facing. We may here remark that it is preferable to construct pipe-valves of some hard, polished material, such as hard-rubber or celluloid, and to let them strike or bed on smooth, soft leather. Valves so constructed are more satisfactory in their action and less liable to go out of order than valves faced with felt and leather in the usual fashion.

The accompanying illustration, Fig. CCXVII., is a Transverse Section of portion of the wind-chest now under consideration, and from it may be gathered the construction and mode of operation of the appliance. A and B are two stop-

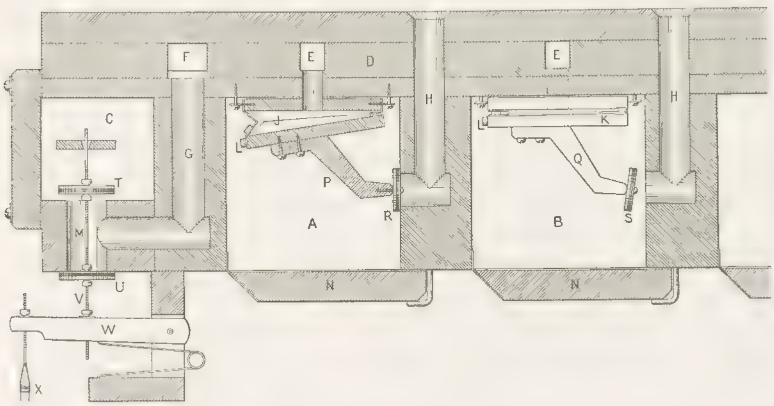


Fig. CCXVII.

chambers charged with compressed air from the main reservoir, through the draw-stop ventils, in the usual manner. C is the clavier action valve-box, constantly charged with compressed air from the main reservoir while the bellows are operated. D is the "tri-part sound- or pipe-board," formed of three layers of wood, the upper and lower of which have their grain running lengthwise of the chest, while the middle layer has its grain running across the chest, favoring the pneumatic channeling therein, branches or offshoots of which appear at E. The pneumatic channels, one for each note of the manual compass, are sunk in the upper portion of the middle layer, as indicated, being carried across the chest between the pipe-ducts, two of which are shown at H. Small branches or offshoots from the pneumatic channels are cut to the line of the pipe-ducts, as indicated at E, for the purpose of connecting them with the pneumatic motors or bellows J and K, through small ducts, one of which is shown at I. The front end of the pneumatic channel at F communicates through the duct G with the valve-throat M. The bottoms of the stop-chambers are closed by the longitudinal boards N,

which can be easily removed should the "gravitating pneumatics" require attention. The construction and location of these pneumatics are clearly shown. Each pneumatic consists of a small bellows J, to the moving board of which is securely fixed a shaped wood arm P, carrying at its rounded end a disc- or pipe-valve R. To aid the extension of the bellows J in closing the entrance to the pipe-duct, its moving board is weighted with small lead plugs L. The position of the pneumatic while its corresponding pipe is not speaking is that shown in the stop-chamber A; and the position assumed by the appliance while a pipe is speaking is that indicated in the stop-chamber B. The principle on which this wind-chest acts is similar to that already described in connection with the Roosevelt-Haskell wind-chest; and, accordingly, need only be briefly touched upon. The valve-throat M has its inner and outer openings commanded by the disc-valves T and U, which are carried, the proper distance apart, on the stem V, which connects the valves with the key action through the lever W and the pull-down tracker X. While the disc-valves are in the position shown, the compressed air from the valve-box C has access, through the duct G, the groove F, the offshoot E, and the small duct I, to the interior of the pneumatic bellows J. The same pressure obtaining inside and outside the bellows allows its weighted moving board with its valve arm to fall and close the entrance to the pipe-duct H. When the manual key is depressed, the disc-valve T is allowed to drop on the inner opening of the valve-throat M, and the disc-valve U to fall away from the outer opening. Communication is now established between the interior of the bellows J and the external air; and the condensed air within the stop-chamber instantly collapses the bellows and opens the pipe-duct H for the passage of the condensed air to the pipe planted above. In the stop-chamber B the bellows K is shown collapsed, the arm Q moved, and the disc-valve S drawn away from the lower opening of the pipe-duct M.

The several systems of construction we have above described have all their pipe-ducts of reasonable length, as have those still more desirable systems which we have yet to consider; but the erroneous impression that the pipe-ducts cannot be too short, or that the pipe-valves cannot be too close to the feet of the corresponding pipes, has led to the devising of certain systems in which the pipe-valves operate, horizontally, immediately under the vertical perforations, in the upper-board of the wind-chest, into which the feet of the pipes enter. In this treatment the pipe-ducts are really less in effective length than the thickness of the upper-board, and, accordingly, may not exceed one inch. While such short pipe-ducts may not be disadvantageous in case of certain classes of labial pipes, they are certainly not advantageous in connection with reed-pipes.

What appears to be the earliest form of the pneumatic ventil wind-chest was patented by Boden, of Halberstadt, in the year 1878. It was designed in accordance with the erroneous conviction just alluded to, and presents all the disadvantages which attend the wind-chests subsequently constructed with a similar horizontal mode of action. This wind-chest is constructed with longitudinal bars and upper-boards and bottom pieces, forming a series of longitudinal stop-chambers. Holes are bored directly through the upper-boards into the stop-chambers, and upon these holes the pipes are planted in the usual manner. Small disc-valves,

carried on vertical wires, open and close the pipe-ducts within the stop-chambers. The bottom pieces are channeled, across the wind-chest, with as many channels as there are notes in the manual compass. These channels are identical in nature and office with those already described in connection with the Haskell membrane-chest. In the upper surface of the bottom pieces, exposed within the stop-chambers, circular depressions are made directly under the pipe-holes above mentioned. These depressions are connected by small perforations with the transverse channels in the bottom pieces, and are covered with membranes which act as reverse-action puffs. The lower ends of the vertical wires or stems of the disc-valves are secured by buttons to the membranes, and the disc-valves are held tightly against the pipe-holes by small spiral springs attached to the buttons of the membranes and to the under side of the guide-bars through which the valve-stems pass. These springs draw the membranes up, and press the disc-valves against the pipe-ducts as long as the condensed air, with which the stop-chambers are charged, is also furnished to the interior of the puffs through the transverse pneumatic channels. Now, when a key is depressed, the valves which command the corresponding pneumatic channel are reversed in position, cutting off the supply of compressed air, and opening the pneumatic channel to the external air. The compressed air within the stop-chambers instantly acts on the membranes, driving them into their depressions, pulling down the disc-valves attached to them, and admitting wind to the pipes. When the key is released, the interiors of the puffs are again filled with the compressed air, and an equilibrium being established, the spiral springs immediately act and close the pipe-ducts.* Throughout this wind-chest the two objectionable features obtain to which allusion has been made; namely, pipe-ducts which in no cases can exceed 1½ inches in length; and pipe-valves which operate horizontally immediately under the pipe-ducts, and are, accordingly, liable to catch and hold any dust, dirt, chips, etc., which may fall through the pipe-ducts. The position of the pipe-valves renders it necessary to remove both the pipes and the upper-boards before they can be reached for cleaning or repairs. Such a necessity should never obtain in connection with a wind-chest, whatever its construction may be.

There are several other pneumatic wind-chests in which short pipe-ducts and horizontal valves with upward action are used. The first of these which we may describe is the wind-chest patented in England, in 1883, by August Gern, Organ Builder, of London.† In the preamble of his Specification the inventor says:

"I provide, as usual, a sound-board having holes through it, one for each pipe, communicating with the wind-chest below, each hole being closed by a valve opening downwards into the wind-chest. I attach this valve to a piston of somewhat greater area than the valve, this piston working freely in a cylinder fixed within the wind-chest and being kept up by a light spring little more than enough to support the weight of the piston and valve. At the bottom of the cylinder there are two passages governed by valves connected to one stem or lever in such a manner that when either is closed, the other is opened, or that both may be

*Illustrations of this wind-chest are given in "Die Theorie und Praxis des Orgelbaues," Plate XLIII., Figs. 1, 2, 3.

†English Letters Patent, No. 2408, dated May 11, 1883.

in a neutral position open. One of these passages communicates with a channel, which I may term the stop-duct, extending the whole length of the wind-chest, and having, at either end, a valve which can be opened by hand. There is one of these channels or ducts to each stop or row of pipes, communicating with all the cylinders of that row. The other passage of each cylinder communicates with a transverse channel, which I may term the key-duct, leading to a point near one of the keys where it is closed by a valve that is opened by the depression of its proper key. The wind-chest being charged with air of the required pressure, the operation is as follows: The performer opens the valve of one or other of the stop-ducts so as to relieve the pressure in that duct, and thereupon all the valves governing the passages from all the cylinders of a row to that duct are closed by the pressure of air in the wind-chest; but as the pressure below all the pistons remains the same as the pressure above them, the pipe-valves remain closed. The performer now depressing a key opens a valve of the key-duct relieving the pressure therein. The piston of the cylinder with which that key-duct communicates being now relieved from pressure below it, descends, opening the valve of the pipe above, so that air from the wind-chest passes to that pipe and causes it to sound. Obviously, each valve cylinder instead of communicating only with one stop-duct, may communicate with two or more, which can be worked as combination stops, and it may communicate with two or more key-ducts, so that the pipe-valve may be worked from several manuals. Also, instead of cylinders and pistons, collapsible or bellows-like vessels may be employed like the pneumatic levers often employed in Organs."

The accompanying illustration will explain all points touched upon in the above fairly clear description. As in this case we have not been able to prepare our drawing from an actual working model of the pneumatic appliance, and as the diagrams in the Patent Specification are of the crudest description, our illustration is not, in point of minute and exact detail, up to the standard we have set for the mechanical drawings in this treatise. While we are acquainted with Mr. Gern's Organs, we have not been granted the opportunity of examining the interior of the wind-chests used in them. The appliance, as shown in the illustration, Fig. CCXVIII., may be briefly described as follows: A is portion of the universal condensed-air chamber of the wind-chest, always fully charged while the Organ is being performed upon. B is the upper- or pipe-board, pierced with the short pipe-duct C. D is the bottom piece, and E is one of the transverse, pneumatic channels, commanded by the manual key-valves in the usual manner. F is the pipe-valve connected by the metal stem H with the piston G. This piston works freely in the metal cylinder K, being pressed upward by the spiral spring I which is held in position by the guide-rod J of the piston. The spiral spring keeps the pipe-valve F against the pipe-duct C as long as compressed air is admitted into the chamber L from the pneumatic channel E, and the corresponding manual key remains untouched. M is the longitudinal stop-duct, commanded by the draw-stop action. When the stop is not drawn the duct M is charged with compressed air identical with that in the general chamber A; but when the stop is drawn the duct M is opened to the external air. Both the pneumatic channel E and the stop-duct M communicate with the chamber L, through the ducts N and O. P and Q are two small valves attached to the under side of a light, metal rocking plate, bent in the manner indicated. This bent plate allows one valve to be open while the other is closed, as shown, or both to be open at the same time. Diagram 2 is a Horizontal Section of the lower part of the appliance, showing the position of

the vertical key- and stop-ducts N and O with respect to each other and to the transverse pneumatic channel E and the longitudinal stop-duct M, which pass at right angles to each other, as indicated by dotted lines.

The action of the appliance is very simple. When the stop is drawn the stop-duct M is opened to the external air, and under the pressure of the condensed air in the chamber L the valve Q is instantly closed over the duct O, and the valve P raised from the duct N. As the pressure is now equal on both surfaces of the piston G it remains, under the action of the spiral spring, with its disc-valve F closing the pipe-duct C. On the depression of the corresponding manual key, the transverse pneumatic channel E is opened to the external air, and the chamber L

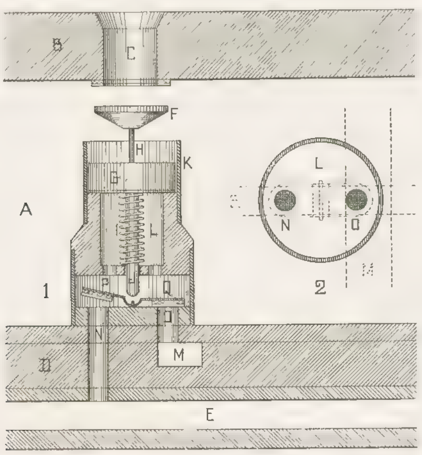


Fig. CCXVIII.

instantly exhausts through the open channel N, allowing the condensed air in the universal chamber A to exert its power on the top surface of the piston and drive it down to the position shown in Diagram 1. As the disc-valve F is drawn from its seat, the condensed air rushes into the duct C and causes the pipe planted thereon to speak. When the key is released, condensed air again fills the pneumatic channel E and the chamber L, and, released from any wind pressure, the piston ascends under the influence of the spiral spring, and closes the pipe-duct. It will be clearly understood that when the stop is put off, and the stop-duct M is charged with the compressed air, the key action can have no effect on the appliance beyond closing the small valve P over the duct N.

If Mr. Gern still uses this appliance in the construction of his wind-chests, he has found it to be reliable and satisfactory in its operation; but, in our estimation, it is attended by several rather serious drawbacks, and must, in the manner in

which it is fixed in the chest, be somewhat difficult to readily reach for cleaning or repairs.

In the year 1887 Gustav Sander, of Brunswick, Germany, took out a patent in this country* for a "pneumatic action," the chief feature of which is a wind-chest that, in certain details, bears a strong resemblance to the earlier chest patented by Gern. The action is vertical, the pipe-valve, placed horizontally, closing by a downward motion, and being opened by a puff acted on by the condensed air of the wind-chest. As in the Gern wind-chest, each pipe-duct is furnished with a separate appliance; while the entire series, belonging to all the stops, is inclosed within a universal compressed-air chamber, which is always fully

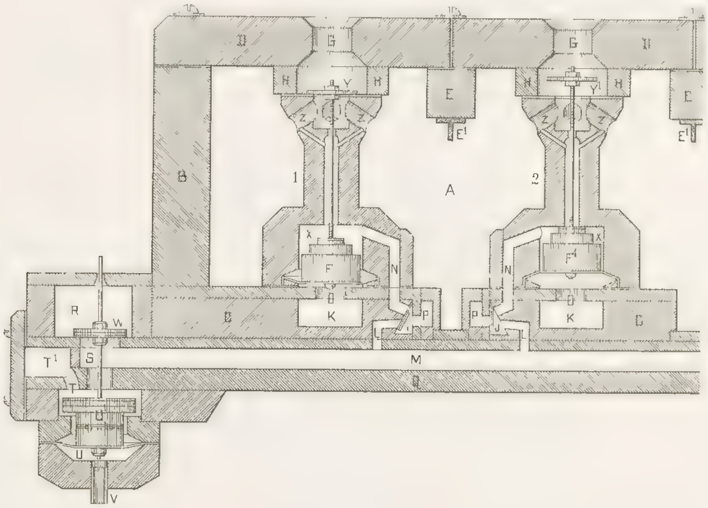


FIG. CCXIX.

charged while the Organ is in use. The somewhat complicated construction of the Sander wind-chest will be readily understood from the accompanying illustration, Fig. CCXIX., and our attendant description. The illustration is a Transverse Section of a portion of the wind-chest, cutting through two of the pneumatic pipe-valves which control the pipe-wind, and the valves directly connected with the key tubular action. A is the general chamber of the wind-chest, constantly charged with compressed air while the Organ is being played. This general chamber is inclosed by end and side pieces—one of which is indicated at B—bottom pieces C, and upper-boards D. The upper-boards, which extend the entire length of the chest, are supported along their inner edges by the longitudinal bearers E, carried on the T-irons E¹. Pipe-ducts are formed in the upper-boards in the manner

* United States Letters Patent, No. 367,666, dated August 2, 1887.

shown at G; and around these ducts, on the under side of the boards, are glued turned rings of hardwood H. The longitudinal bottom pieces C are, like the upper-boards, made in separate divisions, one for each stop, as indicated. The channels K and K^1 extend the entire length of the chamber A, and are furnished with openings O under all the pneumatic pipe-valves. These channels are constantly charged with compressed air from the general chamber A. Underneath the bottom pieces is the transverse channel-board Q, in which are formed the pneumatic channels M, one for each note of the manual clavier. The channel M opens at one end into the valve-throat S, the upper orifice of which communicates with the open-ended chamber R, while its lower orifice communicates with the chamber T, which is charged with compressed air from the longitudinal duct T^1. In the chamber T is the valve U^1, carried on the leather puff U, which is raised by compressed air sent through the pneumatic tube V from the key valve-box. On the stem of the lower valve U^1 is fixed the upper disc-valve W. These valves are adjusted with respect to the valve-throat S and to each other in the manner shown. The pneumatic pipe-valves 1 and 2 have turned and bored bodies of hardwood. In the lower cylindrical chambers X are the wooden cylinders F and F^1, carried on leather puffs, which are actuated by the compressed air from the longitudinal channels K. The cylinders are weighted, and carry leather and felt pads on the upper surface of the weights. Valve-stems of wire rise from the cylinders and carry the disc-valves Y and Y^1 in the manner shown. The disc-valves should be made of celluloid, and bed on the soft leather which covers the tops of the wood bodies. Immediately under the disc-valves are small cylindrical chambers into which the compressed air enters through the oblique holes Z. Small ducts are drilled from these holes into the narrow vertical chambers through which the valve-stems pass, as indicated. The stop action is extremely simple, so far as the wind-chest is concerned, consisting of small longitudinal channels P and P^1, having openings into the triangular recesses in which are hung the light flap-valves I and J, commanding the inner openings of the small ducts L and N. The stop-channels are charged with high-pressure air while the stops remain undrawn, but are opened directly to the atmosphere when the stops are drawn.

The action of this wind-chest may be briefly described as follows: To start with, it must be understood that the universal chamber A, the longitudinal channel K, the duct T^1, the valve-chamber T, the transverse pneumatic channel M, the small duct L, and all the internal cavities and perforations of the pipe-valve 1, are filled with compressed air. The disc-valve Y is held down on its soft leather seat by the weighted cylinder F; and, accordingly, no wind is admitted to the pipe planted on the duct G. This position of rest is indicated in the pipe-valve 1. The stop not being drawn, the compressed air from the channel P has closed, through the medium of the flap-valve I, the communication between the ducts L and N, thereby preventing the key action from having any effect on the pipe-valve. When the stop is drawn, the channel P^1 exhausts into the open air, and the flap-valve J immediately closes its opening, and establishes communication between the ducts L and N, as indicated in the pipe-valve 2. Now, when the corresponding manual key is depressed, highly compressed air is sent through the

pneumatic tube V and under the leather puff U, forcing the valve U^1 upward until it closes the lower orifice of the valve-throat S and the opening from the compressed-air duct T^1. The disc-valve W having, at the same time, been raised from the upper orifice of the valve-throat, the pneumatic channel M immediately exhausts into the atmosphere; and the compressed air in the chamber X, at the same instant, exhausts through the ducts N and L into the channel M and thence to the open air. The compressed air in the channel K^1 now exerts its action, through the opening O, upon the puff over it, forcing the weighted cylinder F^1 upward and opening the disc-valve Y^1. The compressed air in the general chamber A now finds its way to the pipe, passing through the holes Z and around the disc-valve Y^1. On the key being released, the state of equilibrium is immediately restored and the appliance resumes the position shown in pipe-valve 1, while the stop action remains unaffected, in the state indicated at P^1 and J.

The appliance above illustrated and described is unquestionably ingenious, but has the disadvantage of being extremely complicated and very liable to go out of order. The horizontal action of the disc-valves Y is also objectionable. It is difficult to imagine how the pipe-valves are to be readily reached for repairs or renewal. The inventor will not agree with these strictures, for he says in his Specification: "The invention consists in a new and complete construction of a pneumatic wind-chest, by the arrangement of the several parts of which, as well as by its simplicity and the insensibility to temperature, a positive action of all shut-off devices necessary to cause the pipes to sound is obtained."

Should it be desired to command any of the stops in this wind-chest by two independent manual claviers, it is necessary to form two series of transverse pneumatic channels, running side by side, and having independent key-action valves, tubes, etc.; and to furnish each pipe-valve with two draw-stop channels, flap-valves, and side ducts opening into their special pneumatic channels.

Pneumatic wind-chests have been constructed by certain organ builders, in which the pipe-valves operate in the horizontal manner directly under short pipe-ducts, as in the Gern chest; but in which the mechanism is of a very simple character, approaching, in this respect, the chest invented and patented by Boden, of Halberstadt, as previously described. In the wind-chests we now allude to, which are of the compartment, or separate stop-chamber, form of construction, having transverse pneumatic channels commanded by the key action in the usual manner, the pipe-valves are operated by small circular bellows placed, on the bottom pieces, within the stop-chambers. The pipe-valves are attached by wire stems, or round wooden rods, to the top-boards of the bellows, and are pressed against their seats by small springs. As long as the interiors of the bellows are filled with air of the same pressure as that in the stop-chambers, they remain motionless; but the instant they are allowed, through the movement of the key action, to exhaust into the open air, the compressed air in the stop-chambers causes them to collapse, and the pipe-valves being drawn down, wind is admitted to the pipes.

When carefully made and properly adjusted, this form of pneumatic wind-chest is prompt in its action and its repetition is fairly satisfactory. It is open, however, to the objections we have advanced with respect to upward-acting, hori-

zontal pipe-valves, undesirably short pipe-ducts, and a general inaccessibility for repairs.

We shall now briefly describe certain other pneumatic compartment chests, in which the pipe-valves are connected with, and actuated by, diaphragms or puffs formed of leather or some other flexible, air-tight material. In the year 1892 Edwin S. Votey and William D. Wood, Organ Builders, of Detroit, Mich., took out a patent* for a pneumatic compartment chest, in which the disc-valves commanding the pipe-ducts are actuated by a puff of ordinary construction, or what the patentees describe as "a 'pouch pneumatic,' formed of flexible material, as leather, in the nature of a diaphragm capable of being vibrated by the pressure of the air and by the return action of a valve mechanism bearing thereagainst." In the preamble of their patent specification the inventors make the following pertinent remarks :—

"Heretofore in certain styles of Organs it has been customary to employ a single wind-chest common to all or several sets of pipes, a set of pipes consisting of those corresponding to, or controlled by, any particular stop. With this construction and arrangement the larger pipes, it is well known, take more than their proportionate share of the wind in the common wind-chest, thereby to that extent tending to rob the smaller pipes of their requisite quantity of wind. It is well understood, also, that in tuning pipe-organs the pipes are all tuned under the assumption that they will each have their proper and normal quantity of wind when brought into action. This it can have with the single wind-chest as above constructed and arranged when the corresponding stop alone is pulled. When several stops are pulled, causing the corresponding sets of pipes to be sounded simultaneously, then the robbing action above referred to gives to the larger pipes more than their share of air, and subtracts from the smaller pipes the air sufficient to give them their requisite amount, resulting, obviously, in an abnormal and disordered action both of the larger and the smaller pipes, neither sounding normally in exact tune.

"The object of our invention consists, first, in constructing the wind-chest for a single set of pipes in sections, the chest being preferably made in two halves, each half or section supplying wind for a half set of pipes, one-half being located to the right and the other to the left [of the chamber which furnishes the wind to the stop-chambers], thereby permitting the larger pipes to be located toward the outside on either hand, diminishing in size toward the center; secondly, our invention consists in the combination, with independent wind-chests corresponding to the separate stops and sets of pipes, as above stated, of individual valves and pneumatics in each wind-chest operating the individual valves, respectively, and corresponding to and governing the different pipes, and communicating air-channels connecting the pneumatic of any key on the manual with the pneumatic of the corresponding tubes of the several wind-chests in connection ; thirdly, our invention consists in novel features in the construction of the pneumatics and valves in connection with said wind-chests; and our invention, furthermore relates, fourthly, to the general construction, combination, and arrangement of devices and appliances specified, claimed, and illustrated."

A great deal seems to be claimed by the patentees in connection with their wind-chest; but the general principles of its construction were far from novel at the date of the patent. The chief advantages of their wind-chest obtain in its having a special air-chamber for each stop or series of pipes, and a separate valve

* United States Letters Patent, No, 475,831, dated May 31, 1892. Application dated July 20, 1891.

therein for each pipe of the stop; but similar advantages had been previously secured in several compartment or pneumatic ventil wind-chests, as in the case of those illustrated and described in the foregoing pages. The construction of the Votey-Wood wind-chest will be clearly understood from the accompanying illustration, Fig. CCXX., which is a Transverse Section of two stop-chambers, showing the mechanism of their pneumatic pipe-valves.

We may remark that, the drawings given in connection with the Patent Specification being of an incomplete and crude character, we have ventured to represent the stop-chambers in what may be considered a practical form. A and A^1 are

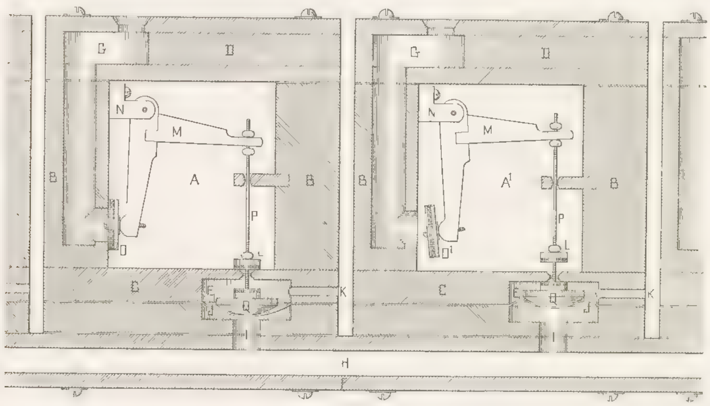


Fig. CCXX.

longitudinal stop-chambers formed by the side bars B, the bottom pieces C, and the upper-boards D. The chambers are charged with compressed air, or the ordinary pipe-wind, from stop-ventils in the usual manner. The upper-boards are constructed of three layers of wood, so as to prevent warping, and to allow the horizontal portions of the pipe-ducts to be easily formed by simply perforating the middle layer, as indicated at G. These ducts are continued vertically through the other layers, that in the bottom layer according with the longer pipe-ducts in the side-bars, as clearly shown. The bottom pieces C are formed of two layers of wood, so as to allow the circular puff-chambers E to be properly formed therein. The layers are here separated by the thin leather, or the flexible, air-tight membrane of which the puffs are made, and which is glued to the surface of the lower layer. The layers are screwed tightly together from the under side of the lower layer. F is a transverse channel-board, and H is one of the pneumatic channels communicating with the lower cavities of the puff-chambers E through the short ducts I. The channel-boards are properly made in narrow widths, containing the channels for three or four notes only, and are screwed to the bottom pieces of the several

stop-chambers. The mechanical portions of the wind-chest may be described as shown in the stop-chamber A: M is a square of hardwood, pivoted in, and supported by, the stud N. To its lower arm is attached the pipe-valve O, so carried as to have sufficient play on its central screw to secure perfect contact with its seat around the orifice of the pipe-duct G. The end of the other arm of the square is forked, and is engaged by the vertical wire P, and held in position by the two leather buttons, as shown. The lower end of this wire passes freely through a hole in the upper layer of the bottom piece C, and is screwed into the turned wooden puff-block Q, which rests on, and is actuated by, the leather or membrane puff J. A small disc of felt and leather is glued to the upper surface of the puff-block, which closes the lesser hole in the bottom piece when the puff is inflated from the pneumatic channel H. This position of the puff is indicated under the stop-chamber A^1. Another small disc of wood, felt, and leather, L, is screwed on the wire P, which closes the same hole in the bottom piece when the puff is exhausted and the pipe-valve O is closed, as indicated in stop-chamber A.

The action is extremely simple and may be thus described: In the stop-chamber A the mechanism is shown at rest. The pneumatic channel H being exhausted, or in direct communication with the external air, through the controlling valve actuated by the key action, the puff J is collapsed, the block Q is lowered, the upper arm of the square M is pulled down by the wire P, and the pipe-valve O is pressed tightly against its seat, cutting off all compressed air from the pipe-duct G. On the depression of the corresponding manual key, the controlling valve admits highly compressed air to the pneumatic channel H, closing at the same instant all communication with the external air: the compressed air rushes through the short duct I into the lower division of the chamber E, and forces upward the puff J, the block Q, and the wire P. This last communicates an upward motion to the arm of the square M through which it passes, and by a corresponding movement of the lower arm withdraws the valve O from the orifice of the pipe-duct G, giving speech to the pipe planted on the upper orifice of the duct. The prompt action of the puff is assisted by the lateral perforation K, which places the upper division of the puff-chamber in direct communication with the external air. The position of all the parts, as just described, is clearly shown in connection with the stop-chamber A^1. The open pipe-valve is shown at O^1.

There are several disadvantages connected with this form of wind-chest, notably its general inaccessibility for quick repairs. To gain access to the internal mechanism of any stop-chamber, the upper-board would have to be removed, and this would involve the removal of all the pipes planted thereon—a very objectionable mode of procedure, as no pipe-work should ever be touched for such a purpose. Allowing that the lower layer of the bottom piece C is made in sections to correspond with the widths of the channel-board F, there would be considerable trouble in getting at any puff for alteration or repair. It must never be forgotten that wherever the flexibility of leather or any membrane has to be depended on in an action in which promptness and perfect repetition are absolute necessities there must be special care taken and provision made for easy access to the parts where the leather is applied, so that the renewal of the leather may be accomplished

quickly, and without requiring the displacement of the pipes or any important portions of the wind-chest.

Several wind-chests have been invented in which the pipe-valves are actuated by leather or membrane puffs, located inside the stop-chambers, and attached to the vertical faces of the longitudinal bars. A wind-chest of this construction, but of somewhat tentative form was patented in England by Charles Frederick Brindley, Organ Builder, of Sheffield, in the year 1897.* The following description from the Specification gives a tolerably clear idea of the mechanical portion of the chest. The patentee says:

"My invention relates to improvements in the appliances or means by which compressed air is admitted from the channel or air chamber into the speaking pipes of an Organ, and to the means of operating the valves.

"In carrying out my invention I will describe the valve mechanism as applied to one pipe only, first, premising that in the upper part of the wall of the air chamber or channel [stop-chamber], a duct or passage is made for the compressed air to pass to the speaking pipe, and in the lower part of the wall, there is an opening communicating with an exhaust appliance of any suitable description. The upper opening is closed by the valve, and the lower one is closed by a strip or disc of leather which I call the motor-disc, and which is raised a little way from the wall by means of a frame of wood. Between the two said openings I fix a standard to which the valve lever is pivoted in or near to its center; to its top end is fixed the valve to close the wind-duct to the speaking pipe, and through its lower end I pass a screw-threaded wire provided with an adjusting nut. The screwed wire also passes through the center of the leather motor-disc, and is secured thereto by a nut upon the wire upon each side of the disc. Between the valve and the fulcrum of the lever and near to the latter, I fix a spring support, say, a piece of wire screwed into the wall and passing through a slot in the lever, its free end provided with an adjusting nut. A light bow spring provided with a central hole is passed over the said wire, with its ends resting upon the valve lever at unequal distances from the fulcrum, and is held against the lever by a nut upon the wire as before described. The tendency of the spring is therefore to close the valve, which is its normal condition, although the area of the motor-disc is greater than that of the valve, both of which are acted upon by the compressed air in the channel. When the pipe is required to speak the exhaust is applied which draws down the motor-disc and the lower end of the lever and opens the valve."

It is unnecessary to add to the above description, or to furnish an illustration from the crude drawing given in the Specification, as the pneumatic wind-chest we now proceed to describe and illustrate is constructed on a similar principle, while in general treatment and appointment it is greatly in advance of the Brindley appliance, as patented.

The compartment wind-chest of which a drawing is given Fig. CCXXI. was used for the first time in the Organ in the Flatbush Dutch Reformed Church, Brooklyn, N. Y., constructed by the Hutchings-Votey Organ Company in the year 1899, or about two years after the Brindley patent is dated. The general treatments of the Brindley and the Hutchings-Votey wind-chests are practically identical, leaving little doubt that the invention belongs to Mr. Charles F. Brindley; while it must be admitted that several marked improvements and the intro-

* English Letters Patent, No. 13,764. Accepted April 9, 1898. Application dated June 4, 1897.

duction of very ingenious draw-stop appliances are due to the designer of the Hutchings-Votey compartment wind-chest. The illustration which is given on page 347 is an accurate reproduction from a working drawing kindly furnished by the organ builders.

Fig. CCXXI. is a Transverse Section through four compartments of the wind-chest, showing different treatments, chiefly connected with the draw-stop appliances. In the generality of pneumatic compartment wind-chests, as in those previously described, the stops are drawn by opening ventils and allowing the organ-wind to enter the compartments or stop-chambers; but in the chest now under consideration all the compartments are constantly charged with the pipe-wind, supplied directly from the wind-trunks, while the Organ is in use. As long as the stops are not drawn, the compressed air or pipe-wind in the compartments remains inoperative, everything being in a state of equilibrium; but when the stops are drawn, this state is destroyed, and the pipe-valves within the stop-chambers become subject to the pneumatic action controlled by the manual keys. The compartments shown at A, B, C, D, and D^1 are formed by the longitudinal bars E, F, G, H, I, and J, the upper-boards K, and the channel-boards L. While the longitudinal bars are securely fixed into the end cheeks of the chest, the longitudinal upper-boards and the transverse channel-boards are made so as to be easily removed to give access to the pipe-valves and the draw-stop appliances. These appliances, shown at O, O^1, O^2, O^3, O^4, and O^5, are held in position against their respective bars by screws and coiled-springs, as described and illustrated on page 214 of the present volume.

The draw-stop appliances within the wind-chest are extremely simple, and comprise nothing liable to go out of order under ordinary conditions. Those indicated in transverse section at O, O^1, O^2, O^4, and O^5 are all alike in construction; but in conjunction with that indicated at O^2 there is the adjunct O^3, which belongs to a high-pressure action, as will be described farther on. As all the single appliances are the same we may confine our present description to the one shown at O. The appliance consists of a small air chamber P, which extends the entire length of the stop-chamber A to which it belongs, and is furnished at one end with valves or pallets, controlled by the pneumatic draw-stop action, by means of which the air chamber is either filled with compressed air or placed in direct communication with the external atmosphere. When the stop is drawn, the chamber is in the latter condition; and when it is not drawn, the chamber is filled with compressed air. Through the inner walls of the chamber P are bored as many holes as there are notes in the compass of the wind-chest; and between each hole and the bar E, to which the appliance is screwed, a shallow groove or Pitman-cell is formed to connect the two short ducts 1 and 2, and to allow a small Pitman-valve to operate between the appliance and the wind-chest bar. The Pitman-valve consists of a disc of fine, smooth leather firmly glued and tacked to the end of a short cylindrical stem of hardwood, well black-leaded to reduce friction to a minimum. This valve is shown at T lying in its hole, with its leather disc within the groove. The hole is made sufficiently large to provide a wind-way around the stem of the valve, as indicated. This clear wind-way is necessary for the opera-

tion of the appliance. When the Pitman-valve is in the position indicated at T, with its leather disc covering the orifice of the duct 1, the stop is not drawn. When the valve is moved back, with its disc covering the hole from the air chamber P, and leaving free the communicating groove between the ducts 1 and 2, the stop is drawn and active. This position of the valve is indicated at T^4. All the rest of the Pitman-valves are in the position which obtains when their respective air chambers are charged with compressed air, and the controlling stops are undrawn. The compound stop appliance shown at O^2 and O^3 is attached to the stop-chamber C, which belongs to a heavy-pressure stop, and is charged with compressed air of a higher pressure than that of the general pipe-wind. The construction and operation of this compound appliance will be understood from the following brief description. The portion at O^2 consists of the longitudinal air chamber P^2 and the small Pitman-valve T^2, similar in all respects to the other stop appliances shown; while the additional portion O^3 comprises the double Pitman-valve Q, operated or controlled by the diaphragm-puff Q^1. While the two valves are in the positions indicated the pipes cannot be sounded, the stop is not drawn. The valve T^2 is held in its position by the compressed air from the chamber P^2, closing the duct 3, and opening the passage to the interior of the diaphragm-pneumatic Q^2; and the double valve Q is held in its position by the compressed air from the pneumatic channel M operating, through the duct 6, on the considerable inner surface of the diaphragm-puff Q^1. This diaphragm is glued to the adjoining disc of the valve Q. The longitudinal channel 7 communicates with the open air. In the condition of the appliance indicated, the duct 3 is charged with the highly compressed organ-wind from the stop-chamber C, passing thence through the free space around the stem of the double Pitman-valve Q; but so long as the stop is not drawn, and the air chamber P^2 remains full of compressed air, the small valve T^2 stays all further progress, and all the mechanism remains at rest, as indicated. Should the pneumatic channel M be exhausted or placed in direct communication with the open air by the key action, the valve Q would be instantly closed by the organ-wind, and the duct 3 placed in communication with the external air through the exhaust channel 7. Still no movement of the pipe-valve within the stop-chamber C will follow, simply because the draw-stop valve T^2 continues to cover the upper orifice of the duct 3. Now, if the stop is drawn while the key is held down, the air chamber P^2 is exhausted and the valve T^2 is instantly moved, by the combined action of suction and pressure, against the orifice of the air chamber P^2. As the passage from the interior of the diaphragm-pneumatic Q^2 is now entirely complete—through the duct 4, the Pitman-cell, the duct 3, and the exhaust channel 7—to the open air, the organ-wind in the stop-chamber C immediately acts on the exposed surface of the diaphragm and drives it into its recess Q^2, moving at the same time the rocking lever R^2 to which it is attached, and opening the disc-valve S^2 fixed to the upper arm of the lever, and admitting the organ-wind to the pipe-duct U^2. When the manual key is released, the pneumatic channel M is filled with compressed air; the puff Q^1 is inflated and moves the valve Q into the position shown in Fig. CCXXI.; the organ-wind passes through the ducts 3 and 4 and fills the diaphragm-pneumatic Q^2; and, a

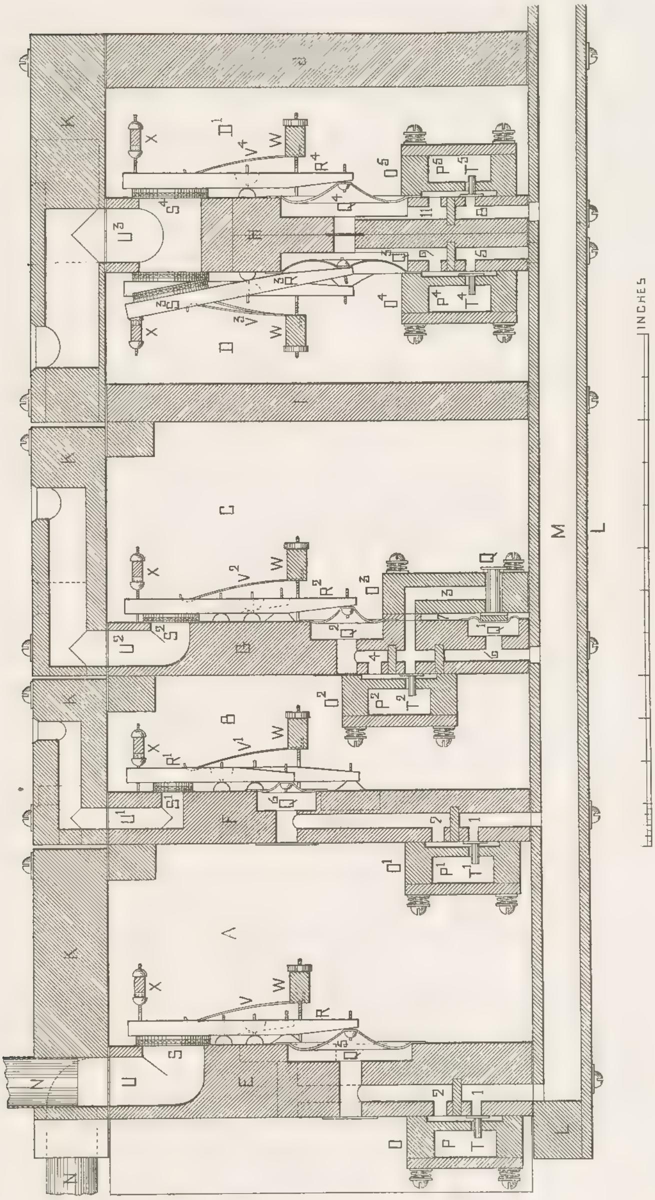


FIG. CCXXI.

state of equilibrium being established on both sides of the diaphragm, the spring V^2 operates on the rocking lever R^2 and closes the disc- or pipe-valve S^2.

The arrangements shown in the stop-chambers D and D^1 are those adopted when a stop is required to speak on two claviers. At O^4 is shown the draw-stop appliance which controls the action of the diaphragm-pneumatics and pipe-valves in the stop-chamber D. The duct 5 communicates with a special pneumatic channel, which is formed alongside the main pneumatic channel M, and which is charged with compressed air and exhausted by the valves commanded by the action of the second clavier—manual or pedal. The duct 8, on the other hand, communicates directly with the main pneumatic channel M, placing the mechanism in the stop-chamber D^1 in connection with the general system of the wind-chest. In the draw-stop appliance O^4 the position of the Pitman-valve T^4 indicates that the stop is drawn, and that the air chamber P^4 is placed in communication with the external atmosphere. Further, the manual key is depressed; the pneumatic channel belonging to the duct 5 is in communication with the open air; the ducts 5 and 9 are in direct communication through their Pitman-cell; the diaphragm of the pneumatic Q^3 is forced inward or collapsed by the pressure of the organ-wind; and the pipe-valve S^3 is removed from the orifice of the pipe-duct U^3, allowing the pipe planted upon the upper-board to speak. In the compartment or stop-chamber D^1 all the mechanism is shown at rest; while the position of the Pitman-valve T^5, in the draw-stop appliance O^5, indicates that the stop is not drawn, and that, accordingly, all communication is shut off between the pneumatic channel M and the interior of the diaphragm-pneumatic Q^4; while, at the same time, the compressed air from the draw-stop chamber P^5, passing thence through the Pitman-cell and the duct 11, fills the interior of the diaphragm-pneumatic Q^4 and institutes an inactive state of equilibrium. While we have indicated all the parts of the mechanism in the other stop-chambers, it is unnecessary to describe them in detail beyond pointing out that the longitudinal rods W are for the support of the springs which close the pipe-valves, and that the smaller longitudinal rods X edged with thick felt, as indicated, are for the purpose of regulating and checking the motion of the rocking levers carrying the pipe-valves. At N N are shown the ends of metal conveyances used for conducting the pipe-wind from the stop-chamber A to large pipes planted at some distance from the wind-chest, or displayed in the case-work. The mechanical portions of this wind-chest are somewhat complicated in construction, and they are not readily reached for adjustment, repairs, or renewal. Absolutely perfect workmanship and the most durable materials are imperative necessities in this form of wind-chest.

In the year 1897, William B. Fleming, of Detroit, Michigan, took out a patent for what is described as a "Pouch-pneumatic for pipe-organs." * This patented appliance, improved in certain minor details, has been used in the construction of several important Organs, with apparent success. Before directing attention to the general construction of the pouch-pneumatic wind-chest, we may properly describe the form and construction of the pouch-pneumatic itself. In the accom-

* United States Letters Patent, No. 594,391, dated Nov. 30, 1897. Application dated Feb. 6, 1897.

panying illustration, Fig. CCXXII., are given Front and Side Views, and Longitudinal and Transverse Sections of this appliance. The pneumatic is formed of a small, oblong block of white pine, 6¼ inches long, ¾ inch thick, and of a width dictated by the diameter of the disc- or pipe-valve it has to carry. This block A is hollowed and partly cut away on one face, in the manner indicated in the Longitudinal Section (1) and the Transverse Section (2), having end pieces, left the full thickness, at A^1. These end pieces are forked, as shown in the Front View (4), to receive the screws by which the pneumatic is attached to the bar of the wind-chest. In the center of the cut-away part of the block is bored the hole B, which, when the pneumatic is otherwise finished, is covered by a disc of leather, as indicated. On each side of this hole, in the hollowed part, is glued the small piece of

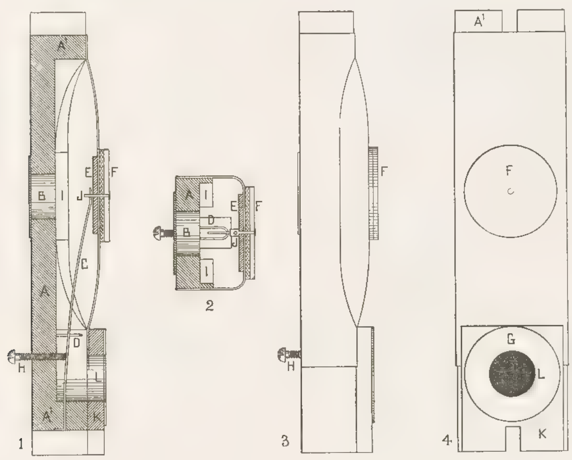


Fig. CCXXII.

thick and soft felt I to receive and silence the impact of the pipe-valve when the flexible covering collapses. In the center of a piece of thin and suitable leather or some air-tight material forming the flexible covering of the pneumatic, is glued the pipe-valve, formed of a disc of fine felt faced with pallet-leather (dressed side outward), and having a corresponding disc of millboard glued against it, on the inner side of the flexible covering. The pipe-valve is shown at F in all the illustrations, while the millboard backing is indicated at E in the Sections. The discs are further secured by the small brass pin J, which has an eye on the millboard side for the reception of the free end of the valve-spring C. Before the pouch is formed, by gluing the edges of the flexible covering to the block, the steel wire spring C is securely fixed in the lower end of the block, and held in position by the wire staple D. This spring has its strength adjusted by the screw H. A

small extra piece of thin leather is glued on the inner side of the flexible covering where it comes in contact with the spring in collapsing, to prevent the spring injuring the covering. This is not shown in the Longitudinal Section. The flexible covering with the pipe-valve attached is now glued to the sides and end pieces of the block; and the pneumatic is completed by the addition of the thin, perforated piece of wood K, faced around its perforation L with the ring of soft leather G. The Side View (3) and the Front View (4) show the pouch-pneumatic in its finished state, ready for insertion in the wind-chest. We may remark that in this form of pneumatic valve, as in all others which act in a similar manner, the promptness of action depends on the use of a pipe-wind of considerable pressure, a returning spring of adequate strength, and a flexible covering that is not liable to stiffen under varying atmospheric conditions. Promptness of action and absolutely instantaneous repetition are essentials in a perfectly satisfactory pneumatic mechanism. From our own experience, and also judging from a theoretical standpoint, we are disposed to doubt the prompt action and satisfactory repetition of a valve commanded by a membrane or pouch presenting so large a surface, and inclosing so large a quantity of air; for it must be borne in mind that at every opening and closing of the pipe-valve the interior of the so-called pouch has to be exhausted and refilled. In the smaller pouch-pneumatics, in the treble octaves of the wind-chest, this exhausting and refilling may be quickly accomplished; but in the larger pneumatics, in the bass and tenor octaves, we seriously doubt if a sufficiently prompt action is possible under the conditions set forth in the Patent Specification. The action would be greatly improved, we venture to think, if, instead of a spring being alone depended on for the return of the pipe-valve to its seat, wind of higher pressure than the pipe-wind were employed to inflate the pouch-pneumatic. Other inventors have found high-pressure air absolutely necessary for the proper action of membranes and of diaphragm-valves.

In the illustration, Fig. CCXXIII., is given a Transverse Section of portion of a Fleming wind-chest and its attendant valve-box, showing the pouch-pneumatics, above described, occupying their proper positions in the stop-chambers. The action commanded by the manual claviers is tubular-pneumatic. The tube which extends from the key valve-box to the wind-chest pneumatic action, belonging to any note of the clavier, enters at A and communicates with the interior of the primary pneumatic B. This primary is, as indicated, a small square bellows. To the movable board of this bellows are attached, by the vertical stem C, the twin disc-valves D, which alternately open and close orifices which communicate with the interior of the compressed-air chamber E, and the external air at F. The disc-valves are held, as long as the commanding key remains untouched, in the positions shown by the adjustable spring G. The compressed air in the chamber E, passing under the lower disc-valve, enters the adjacent horizontal channel, and fills the secondary pneumatic I—a square bellows somewhat larger than the primary B. To the lower and movable board of the secondary pneumatic is attached the pendant stem J, carrying the two disc-valves K and L, which alternately open and close orifices which communicate with the compressed-air chamber at M, and with the external air at N. These disc-valves are held in the positions

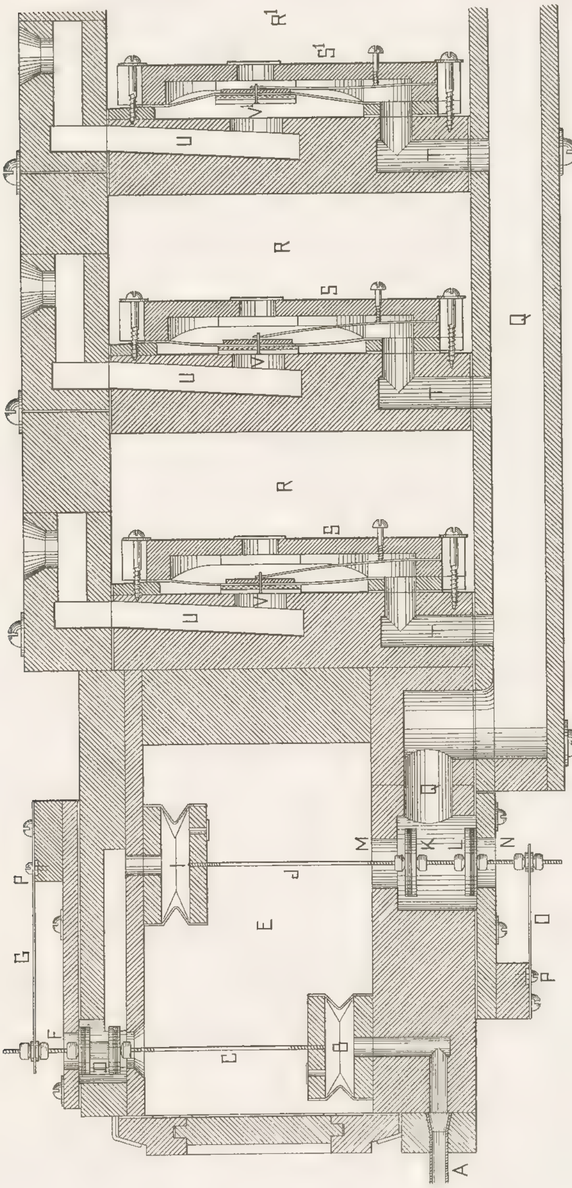


Fig. CCXXIII.

shown by the spring O. Both the springs G and O are adjusted to the requisite strength by the binding-screws P P. The larger disc-valves K and L command the pneumatic channel Q, admitting compressed air into it, or allowing it to exhaust into the open air through the orifice N. R, R, and R^1 are three stop-chambers in which are fixed the pouch-pneumatics S, S, and S^1. The interiors of the pouches of these pneumatics communicate with the transverse pneumatic channel Q through the ducts T. The flat ducts through which the pipe-wind, which fills the stop-chambers when the stops are drawn, is conveyed to the pipes planted on the upper-boards, are indicated at U, their lower circular orifices being commanded by the pipe-valves V and V^1, attached to the pouch-pneumatics. The position of the valves when the pipes are silent is shown at V; while their position when the pipes are speaking is indicated at V^1.

The action of the mechanism above described is very simple. When a manual key is depressed, the tube A is opened to the external air; the compressed air in the chamber E collapses the small primary pneumatic B, drawing down the disc-valves D, and opening the channel to the external air; the compressed air in the chamber E now collapses the larger motor I, drawing up the disc-valves K and L, closing the orifice M, and opening the lower orifice N, allowing the pouch-pneumatics to exhaust, through the ducts T and the transverse channel Q, into the open air; and, finally, the compressed air, or pipe-wind, in the stop-chambers R, collapse the flexible leather pouches, draw their pipe-valves away from the lower orifices of the pipe-ducts U, and admit the wind to the pipes planted on the chest. The position of the pouch and its pipe-valve, in its exhausted condition, is indicated at S^1 and V^1, in stop-chamber R^1. On the release of the key, an action essentially the reverse of that just described takes place; and through the pressure of the springs G and O, and the equilibrium immediately established in the compressed air of all the moving parts of the wind-chest, the mechanism assumes the state of rest represented in the compressed-air chamber E and in the stop-chambers R R. To remove any one of the pouch-pneumatics for repair or renewal, it is only necessary to remove a bottom channel-board, and draw the lower binding screw which holds the pneumatic firmly against the opening of its duct. A new pneumatic can be slipped in and screwed tight and the channel-board replaced within the lapse of ten minutes, provided, of course, that easy access is furnished to the channel-boards.

In the preceding pages of the present Chapter we have described and illustrated two compartment wind-chests invented by Mr. Philipp Wirsching, of Salem, Ohio; and we have now the privilege, through his kind coöperation, of describing and illustrating his latest achievement in this direction—a compartment wind-chest, which is characterized by great simplicity of construction and easy accessibility for correction or repairs. Properly made of the most suitable materials, this wind-chest would certainly last for a long time without calling for any attention: and when, in the course of time, the leather or flexible diaphragm which carries the simple pipe-valves becomes sluggish or otherwise imperfect through the constant action of the air in contact with it, the entire series of pipe-valves can be quickly removed from any stop-chamber, restored to perfect condition, and replaced, with the expenditure of little time and at a trifling cost. This can be done without in

any way crippling the other stop-chambers of the instrument; and without rendering it necessary to move a single pipe.

In the illustration, Fig. CCXXIV., on page 355, is given a Transverse Section (1) of two stop-chambers of the above-mentioned wind-chest, and its attendant pneumatic valve-box, or what is designated by Mr. Wirsching the "pneumatic station." This station can be located close to the wind-chest, in the manner shown, or in any other convenient locality, as the arrangement of the interior of the Organ may dictate. When placed away from the wind-chest, it will only be necessary to connect the valve-ducts of the pneumatic station with the transverse pneumatic channels in the upper-board of the wind-chest by means of tubes.* Diagram 2 is a Side View of a diaphragm- or pipe-valve bar, with a Longitudinal Section of the corresponding part of the upper-board of the chest. In Diagram 1, A and B are stop-chambers, placed at a short distance from each other (as required by the stops planted over them), and formed by the side bars C and the upper connecting pieces D, and closed below by the movable boards E. Projecting from the inner faces of the side bars are the longitudinal pieces F, through which the pipe-ducts are bored and connected with corresponding ducts in the side bars, as indicated at G and H. Running longitudinally along the center of the stop-chambers are the diaphragm or pipe-valve bars K. These are leathered on their upper edges, and tightly screwed to the pieces D. The stop-chambers, in their complete form, are securely attached to the under side of the upper-board M by means of bolts which pass through the upper-board and the side bars of the stop-chambers. The tightening nuts of these bolts are shown in the illustration. The bolts should be fitted with coiled springs to allow for expansion and contraction. By this simple method of fixture, any stop-chamber can be removed from the upper-board without in any way interfering with the other stop-chambers or the pipe-work planted on the upper-board. The most noteworthy feature of the invention is the formation of the complete diaphragm- or pipe-valve bar K. This will be readily understood from what is shown in Diagrams 1 and 2. The bar K has a series of circular recesses—one for each note in the manual compass—cut in its sides and staggered in their disposition, as indicated by the lined and dotted circles in Diagram 2. These recesses or pneumatic chambers are all about $\frac{5}{16}$ inch deep, and vary in diameter according to the sizes of the pipe-valves required for the proper supply of wind to the different-sized pipes of the several stops planted on the wind-chest. Sections of two of these pneumatic chambers are shown at L in Diagram 1. A hole about $\frac{3}{8}$ inch in diameter is bored from the top edge of the bar into the back and side of each chamber, as shown at T, which communicates, when the bar K is fixed in position, with corresponding holes bored in the piece D and the bottom layer of the upper-board M into the transverse pneumatic channel N, as shown in section in Diagram 1, and indicated by vertical, dotted lines in Diagram 2. Both sides of the bar K are covered with thin leather, which extends over, and is somewhat depressed into, the circular pneumatic chambers, so as to

* This treatment is contemplated in connection with the Wirsching wind-chest illustrated in Fig. CCVIII., in which the tube from the pneumatic channel L in the upper-board to a detached pneumatic station is shown, in part, at O.

carry, and give the requisite play to, the pipe-valves. These valves are discs of cardboard, felt, and pallet-leather, glued in a central position to the diaphragms which cover the chambers. When the diaphragms have their disc-valves attached to them, they are fully inflated, and their free margins surrounding the valves are saturated with hot tallow, which renders the leather air-tight and weather-resisting. As pure tallow never dries or becomes hard, the continued flexibility of the diaphragms is practically secured. The diaphragms are shown in section at J in Diagram 1, and in front view in Diagram 2; while the disc-valves are similarly shown at I in both diagrams. When a diaphragm is inflated by highly compressed air from the pneumatic channel with which it is connected, the disc-valve rests tightly against its seat around the corresponding pipe-duct. This position of the disc-valve is indicated in stop-chamber A. When the pneumatic chamber is exhausted, and the diaphragm is driven inward by the force of the pipe-wind in the stop-chamber, the disc-valve is removed from the orifice of the corresponding pipe-duct, and the pipe standing on the upper end of the duct is made to speak. This position of the disc-valve is shown at I in the stop-chamber B. The remaining portion of the wind-chest to be described is the upper-board M. This is properly formed of three layers of wood, in the middle one of which are formed the series of transverse pneumatic channels—one for each note of the compass—which convey highly compressed air from the pneumatic station to the diaphragm-pneumatics as long as the manual keys remain untouched; and which exhaust the pneumatic chambers when the respective keys are depressed.

Having outlined the construction of the wind-chest proper, we may now briefly describe the formation of the pneumatic station, to use Mr. Wirsching's terminology. W is the valve-box, formed by the bottom O, the side P, and the top piece Q, all of which pieces extend the entire length of the wind-chest and are bored with the several valve-ducts and channels, in the manner clearly shown in the Transverse Section, which is cut through the ducts and the pneumatics belonging to a single note. The valve-box is closed in front by the movable board R. On the top piece Q is fixed the tube-bar S, which receives the ends of the pneumatic tubes from the distant key valve-appliance. An end of one of these tubes is shown at U^1. The duct U into which this tube is inserted is carried through the bar S and the top piece Q into the small primary pneumatic or motor-bellows V. Attached to the movable board of this bellows is the valve-stem 5, carrying the twin disc-valves 1 and 2, which command the interior and exterior orifices or ports of the duct Z. This duct communicates with the interior of the secondary or motor-bellows X, as clearly indicated. From the top-board of the bellows X rises the valve-stem 6, carrying the twin disc-valves 3 and 4, which command the exterior and interior orifices or ports of the larger duct Y, the other end of which opens into the pneumatic channel N in the upper-board of the wind-chest proper. It may either do so directly, as shown in the illustration, or through a tube of any convenient length when the pneumatic station is placed away from the immediate neighborhood of the chest, as already mentioned. In addition to what has above been described, is the small feed-duct 7, which connects the vertical duct U with the interior of the valve-box, its feed being regulated by means of the screw 8.

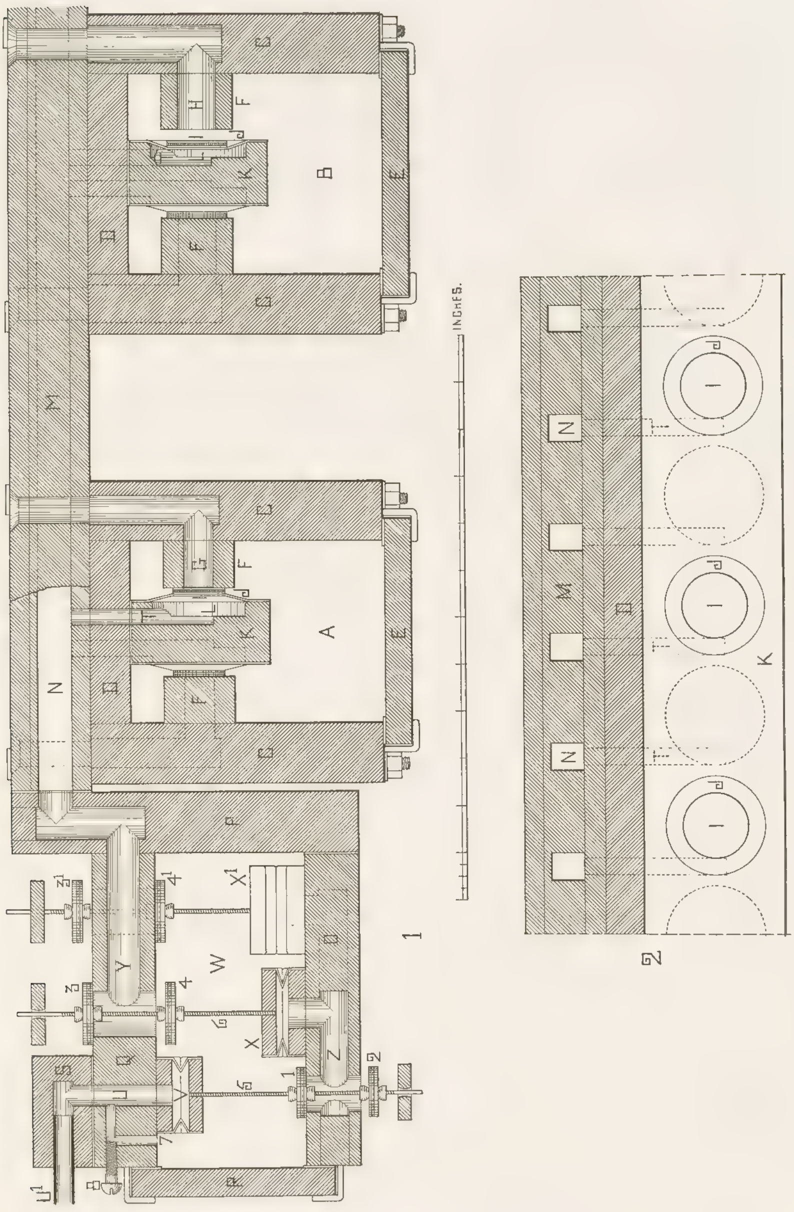


Fig. CCXXIV.

The other details of the appliance are so clearly shown as to require no description.

The action of the wind-chest and its attendant pneümatic station is very simple, and may be described as follows: It is to be understood that when a stop is drawn, the corresponding stop-chamber is charged with pipe-wind from the draw-stop ventil, in the usual manner; and that both the key pallet-box and the pneumatic station are filled with compressed air of a higher pressure than the pipe-wind. While the commanding manual key is not depressed, the entire pneumatic mechanism remains at rest, just as it is represented in the pneumatic station and in the stop-chamber A of the wind-chest in Diagram 1. The primary pneumatic V is filled with the compressed air from the chamber W, furnished through the feed-duct 7 and the duct U, and, being so filled, it allows the upper disc-valve 1 to close the interior orifice of the duct Z, while it removes the lower disc-valve 2 away from the exterior orifice, and allows the secondary pneumatic X to exhaust into the open air, under the pressure of the air in the chamber W. This secondary pneumatic in collapsing closes the disc-valve 3 over the exterior orifice of the duct Y, and opens the interior orifice of the duct by drawing down the disc-valve 4. The highly compressed air passes through the duct Y, the pneumatic channel N, and the small duct T, into the diaphragm-pneumatic L, where it expands the diaphragm J and presses the pipe-valve I against its seat, cutting off the wind in the stop-chamber from the pipe-duct G. Now, when the manual key is depressed, the action above described is instantly reversed. By the movement of the key-valve or pallet the pneumatic tube U^1 is placed in communication with the open air; the primary pneumatic V collapses under the pressure of the condensed air in the chamber W, drawing the disc-valve 1 from its seat, and closing the exterior orifice of the duct Z by seating the disc-valve 2 firmly over it. The compressed air in the chamber W now enters the duct Z and the interior of the secondary pneumatic X, instituting an equilibrium, and allowing the pneumatic to expand under the pressure of the highly-compressed air on the large disc-valves 3 and 4. This action closes the interior orifice of the large duct Y and opens the exterior orifice to the free air. The new positions of the pneumatic (now inflated) and the twin disc-valves are indicated at X^1, 3^1, and 4^1; which secondary pneumatic and its attached disc-valves belong to an adjoining note commanded by another key. The opening of duct Y to the free air allows the pneumatic channel N and all the diaphragm-pneumatics connected with it to exhaust, the result being that the pipe-valves in all the stop-chambers which are charged with pipe-wind collapse under the pressure of that wind and allow the associated pipes to speak.

It will be seen from the above description that this Wirsching action belongs to a special tubular-pneumatic system, differing from those outlined in the preceding Chapter. It resembles the fifth system, mentioned on page 288, inasmuch as natural exhaust is all that the key-valves command; but it differs essentially in the use of high-pressure action-wind. The reasonable objection against the necessity of employing different pressures of wind, especially in small Organs, is largely overcome by the use of the compound bellows invented by Mr. Wirsching. In this novel bellows two or more pressures are readily obtained.

Mr. Frederick W. Hedgeland in his Letters Patent, dated June 14, 1892, illustrates and describes a compound bellows employed for the same purpose as the Wirsching compound bellows. This bellows is briefly described in the extract from the Patent Specification given on page 331. While the general principle of its construction is similar to that of the Wirsching bellows, the latter is greatly superior to the Hedgeland bellows in all practical details.

A compartment wind-chest, constructed on the same general principles as those which obtain in the formation of the Wirsching chest just described, was invented and patented by Mr. Thomas Pendlebury, Organ Builder, of Leigh, Lancashire, England.* In the preamble of his Patent Specification the inventor says:

"This invention refers to the wind-chests of pipe-organs, and has for its object to provide a more satisfactory arrangement of membranes and membrane tubes than hitherto provided for controlling the admission of wind to the organ pipes. Heretofore, the most common arrangement has been wooden tubes extending downwards from the top boards to the floor of the stop-compartments, with membranes of leather in the bottom boards, forced upwards and against the tube ends by auxiliary bellows giving a preponderance of pressure over that in the stop-compartments, but owing to the shrinking or swelling of the divisions of the wind-chest, and the consequent disturbance of the adjustment of the membranes, also owing to the possibilities of dirt lodging upon the membranes when the pipes are removed and preventing the membranes closing, the arrangement has been anything but satisfactory.

"In other arrangements the membranes control openings in the sides of the stop-compartments, or in the bottom boards, but in each case an extra pressure of wind is required to hold the membranes closed against the pressure of the wind within the stop-compartment, which, besides adding to the cost and labor of working the Organ, subjects the membranes to considerable strain.

"According to this invention, both the membranes and tubes, and the necessary wind-ways therefor, are arranged in the top boards of the stop-compartments, and the tubes are, by preference, made of metal, and in the form of mitered conveyances, with one end of each tightly fitting and glued into a pipe-hole, and the other end lying immediately below its membrane which is so mounted that it has a natural tendency to close the tube or conveyance by its own weight, and, therefore, does not require an extra pressure of wind to keep it closed, and is not subjected to severe strain. Furthermore, such membrane cannot possibly be prevented from closing by dirt falling down the pipe-holes when the pipes are lifted out; and by having the tubes, membranes, and the necessary wind-ways therefor, all secured to, formed in, and removable with the upper-boards, allowance is made for the conveyances being perfectly adjusted to the membranes, whilst their relative positions are in no way affected by the swelling or shrinking of the divisions of the wind-chest. Moreover, the distance between the top and bottom boards is not limited by the tube, and, therefore, a greater depth can be given for more air space and a steadier tone."

To enable the reader to clearly understand the above description, and to compare the construction of the Pendlebury chest with the formation of the Wirsching chest, we give, in Fig. CCXXV., a Transverse Section of two stop-chambers, rendered in a somewhat practical form from the extremely insufficient and crude drawings given in the Patent Specification. A and B are two stop-chambers

* English Letters Patent, No. 7102, dated May 14, 1903. Application dated March 27, 1903.

formed by the longitudinal bars C, the longitudinal bottom pieces D, and the transverse upper-boards E. The disposition of the upper-boards transversely is very unusual, being adopted in this chest to enable the transverse pneumatic channels to be cut along the edges of the boards. These channels are completed by leather glued along the edges of the upper-boards. Instead of each upper-board being planted with all the pipes belonging to a single stop, as is usually the case, the transverse upper-boards of the Pendlebury wind-chest are devoted to one, two or four notes of all the stops planted on the chest. When the boards carry four notes, as in the higher treble octaves, they have two pneumatic channels cut in each edge. F and G are the pipe-ducts in the form of mitered, metal conveyances, one end of each being securely glued in a pipe hole, while the other end is turned up so as to receive the leather diaphragm-pneumatic, as indicated at H. The ends of the pipe-ducts have rounded rims for the diaphragms to bed against. The

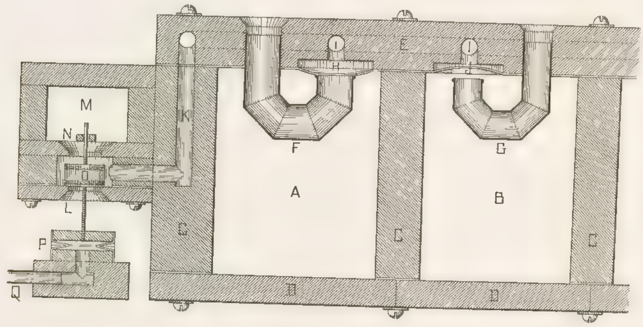


Fig. CCXXV.

pneumatics are shallow, circular recesses in the under side of the upper-boards covered with fine flexible leather so fitted as to assume the outward and inward positions indicated at H and J. The pneumatics communicate with the transverse pneumatic channel (indicated by dotted lines) through the ducts I. At H the diaphragm or "membrane" of the pneumatic is shown in the position it is said to assume while the pneumatic channel and the chamber of the pneumatic are filled with the ordinary organ-wind: and at J the diaphragm is shown blown away from the mouth of the pipe-duct G by the force of the organ-wind in the stop-chamber B, the transverse pneumatic channel being exhausted through the duct K and the open-air port L, the valve O being raised for the purpose by the key action. The action of the double disc-valve O is precisely similar to that described in connection with several wind-chests illustrated in the preceding pages. It is only necessary to add that the chamber M, which extends the length of the wind-chest, is constantly charged with the ordinary organ-wind while the Organ is being used.

The small motor-bellows P, which operates the valve O, is inflated and exhausted through the tube Q, which comes from the key valve-box in the usual manner.

The wind-chest just illustrated and described presents some objectionable features. The preparation and fitting of sixty-one mitered, metal pipe-ducts for each stop planted on the chest must be both troublesome and expensive. The whole of the pneumatic work being attached to the upper-boards, renders it necessary when any diaphragm goes out of order or becomes sluggish to remove the upper-board and all the pipes planted thereon, completely crippling the entire wind-chest for the time. In what manner can the prompt return and closing of the leather diaphragm be insured, seeing that it is expected to fall of its own weight as the equilibrium is instituted? Mr. Pendlebury says that an extra pressure of wind is not required to inflate the diaphragm and keep the pipe-duct closed; but, judging by our own experience, as well as from the practice of successful organ builders, we are strongly of opinion that a higher pressure is absolutely necessary to secure a prompt inflation of the diaphragm and a satisfactory repetition. The natural tendency of leather when in the form of a diaphragm is to become stiff and sluggish under continued changes of the atmosphere, and, such being the case, something more than mere unassisted gravity has to be depended upon for instantaneous action. From all points of view the Wirsching wind-chest illustrated in Fig. CCXXIV. is superior to that patented by Mr. Pendlebury. The Wirsching wind-chest is perfect in its action, and its attack and repetition leaves nothing to be desired.

It is but right to point out that Mr. Pendlebury does not confine himself to the use of the mitered metal pipe-ducts as above described. In his Patent Specification he adds:

> "In lieu of metal tubes I may employ wooden tubes or blocks, the passages for the air being formed by right angled borings, or diagonal borings, or parallel borings and a groove, the open sides or passages in the two last named arrangements being closed by strips of leather glued on.
>
> "To ensure an effectual closing of the outlets, each membrane has a disc of wood attached to it (leathered on the under side), or the mouth of the outlet is raised to form a seating; but for all practical purposes I prefer the metal tubes."

In the diagrams given in the Specification, the "wooden tubes or blocks" are shown attached to the under surface of the upper-boards, within the stop-chambers, their pipe-ducts being disposed with respect to the pendant diaphragms in the same manner as shown in Fig. CCXXV. The adoption of the wooden blocks does not affect the objections above stated.

It has been our aim in the present Chapter to lay before the student of the art of organ-building all the representative systems of pneumatic ventil wind-chest construction, and we venture to think that we have practically covered the subject. We are aware that there are numerous modifications of the several systems, to which different organ builders have given their allegiance, chiefly with the view of claiming, for trade purposes, some real or fancied superiority over the forms adopted by rival builders. It will be found, however, that these several methods

of construction strictly belong to some of the systems we have described and illustrated, and that they, at most, present a distinction without a difference. That the present Chapter, like all the Chapters of our treatise, is imperfect and circumscribed we freely admit; but a work of even this large size has limitations which must be observed. It would take many volumes the size of this to do justice to so vast a subject as the science and art of organ construction and appointment.

CHAPTER XXX.

THE DRAW-STOP ACTION.

—MECHANICAL AND PNEUMATIC.—

THE Draw-stop Action is that portion of the mechanism of the Organ which enables the performer, seated at the claviers, to command the several stops contained in the instrument, bringing them on and throwing them off the claviers, so to speak, at his will. It is not known at what date the first mechanical draw-stop action, properly so-called, was added to the Organ; but it is quite certain that some simple means of giving voice to and of silencing its different ranks of pipes obtained at a very early date. These means were commonly in the form of perforated sliders, having no mechanism connected with them, and being moved directly by hand. In the Organs represented in Figs. XI. and XIII., given in Volume I., the ends of their sliders are clearly shown without any mechanical attachments. When the Organ was developed and assumed an important form, its sliders and pallet wind-chests, planted with numerous stops, were somewhat clumsy in their construction, and its draw-stop action was correspondingly crude and extremely heavy, requiring a leverage so great as to call for a draw of many inches at the stop-jambs to move the badly-fitted sliders of the wind-chests. So great was the necessary and inconvenient extent of this draw, that instead of draw-stop knobs and rods, having a direct forward motion, long projecting levers were sometimes used, which the performer seated at the claviers had to draw toward him with considerable force, to bring on the stops, and release or push from him when he desired to throw off the stops. We found such crude draw-stop actions still existing during our survey of Continental Organs, and notably in the Organ in the Cathedral of Fribourg, in Switzerland.

The draw-stop actions introduced in modern Organs, constructed on purely mechanical lines, and with the old-style slider and pallet wind-chests, are usually of the simplest form, but perfectly adapted for the work they have to do. These

actions comprise, in addition to the external draw-stop knobs and rods, internal rods of wood, which push and pull, known as "traces;" squares or bent levers, usually of brass or iron, employed to carry the action in any required direction; strong rollers of wood or iron, called "trundles," pivoted, and furnished with projecting arms to engage the traces; and rocking levers or cranked rollers, to operate directly on the projecting ends of the wind-chest sliders. In the accompanying diagram, Fig. CCXXVI., are shown some of the portions mentioned above. A is the knob and cylindrical rod which projects from the draw-stop jamb adjoining the manual claviers; B B are the traces; C is the trundle with its arms projecting at right angles; D is the rocking lever, connected with the shorter trace B, and engaged in a small slot in the projecting end of the slider E. The directions of the

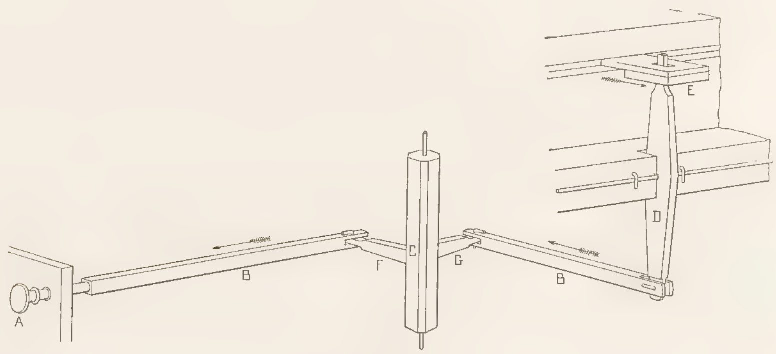


Fig. CCXXVI.

combined movements while the stop is being drawn are indicated by the arrows. When the slider E is being pushed in, to shut off the wind from the associated pipes or stop, the action in all its parts has the reverse movement, caused by the performer pushing in the knob A. To enable this to be done without too much exertion the draw-stop knob is made to travel through a greater distance than that required for the slider E. This is accomplished by making the arm F of the trundle longer than the arm G, as indicated. If found more convenient, this desirable leverage can be secured by making the lower arm of the rocking lever longer than the upper, in the manner shown in Fig. CCXXIX. In the generality of the large German Organs built during the seventeenth and eighteenth centuries this amount of leverage was greatly exceeded. Indeed, in numerous cases the draw-stop knobs had to be moved to so great an extent as to be practically beyond the command of the performer seated at the claviers: they had, accordingly, to be operated by an assistant; or by two assistants, one at each side of the performer, as we saw during an organ recital in one of the churches in Holland. The assistants had to pull and push with the activity and much of the motions of

acrobats, using both hands and shoulders in drawing out and pushing in the stop-handles, singly or in groups, as the performer or the music required. The whole affair was little short of ludicrous, although to those engaged it was quite a serious business.

In Fig. CCXXVII. is shown the manner in which a cranked roller takes the place of the rocking lever. The crank A of the vertical iron roller B engages the projecting end of the slider C, its circular pin being inserted in the small slot in the slider. The roller is moved by the trace D, which is forked on, and pinned to, the roller arm E. To give the necessary leverage the arm E is made considerably longer than the operative throw of the crank A. When the trace D is

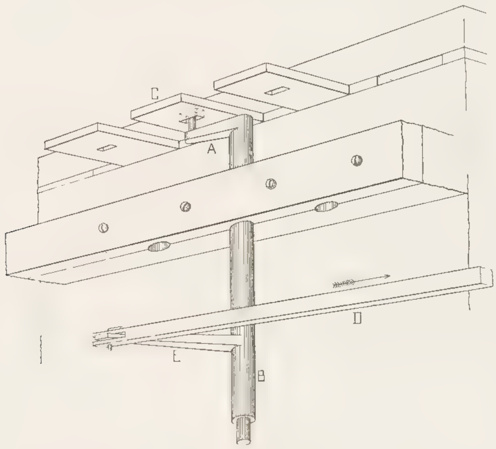


Fig. CCXXVII.

moved in the direction indicated by the arrow, the motion imparted to the roller throws its crank outward and draws the slider. When the trace is moved in the opposite direction to that indicated by the arrow, the slider is pushed in by the reverse motion of the crank. When neatly and carefully made, this form of draw-stop action is highly suitable for Chamber Organs having slider and pallet wind-chests.

It is desirable to have the stop-jambs placed obliquely, so that the draw-stop knobs may face toward the performer, and be easily drawn by him while he is seated at the keys. But with the ordinary mechanical action, as above described, this oblique disposition causes considerable complexity. It entails the introduction of bent levers to change the oblique movement of the draw-stop rods into a direct movement in the traces, and there is considerable difficulty in so disposing the bent levers as to prevent their interfering with each other when moved. The difficulty alluded to has been found so great that organ builders have very rarely adopted the oblique disposition with the old-fashioned mechanical draw-stop action.

No difficulty whatever attends the adoption of oblique or concave stop-jambs when the action is tubular-pneumatic or electro-pneumatic. When the pneumatic lever action is used, as obtains in the large Organs constructed by the late M. Cavaillé-Coll and other French builders, the movement of the draw-stop knobs becomes very simple and short, connection between their rods and the pneumatic levers being made by light tracker-work. With an action of this description the draw-stop knobs can be disposed in any desirable manner. In the detached consoles of large Organs, the most convenient disposition is in either concave or oblique, stepped jambs. Probably the most pronounced example of this disposition, in which concave, stepped jambs are introduced, is to be found in the console of the Organ built by the Los Angeles Art Organ Company, and erected in the Festival Music Hall of the St. Louis Exposition, 1904. A Front View of this console is given in Plate VI. It will be seen that in addition to the concave disposition, the draw-stop knobs have oblique name plates. The action of this console is entirely electric. Both oblique and concave dispositions have one great disadvantage; namely, they do not properly lend themselves to the introduction of an automatic adjustable combination action—one of the most important adjuncts to the modern Organ. With such a combination action, the straight, stepped stop-jambs with oblique-faced knobs cease to be inconvenient, even when the Organ is of large dimensions, simply because the performer, when his required combinations are set, has very little, if any, necessity to touch the draw-stop knobs during the rendition of a musical work.

In large Organs in which the tracker and pneumatic lever action is used, the sliders of their wind-chests are usually operated by pneumatic motors, placed directly opposite the ends of their respective sliders or in some other convenient locality, and connected by rods or traces directly with the sliders, or with the longer arms of rocking levers, acting on the sliders in the manner shown in Fig. CCXXVI. The Organ in the Albert Hall, Sheffield, constructed by M. A. Cavaillé-Coll, affords an admirable example of the latter disposition. Here the pneumatic motors are placed in the *rez-de-chaussée*, or lowest stage of the instrument, conveniently under their respective wind-chests located in the higher stages. In Fig. CCXXVIII. is given a Longitudinal Section of the draw-stop pneumatic motor introduced by M. Cavaillé-Coll in this and other large instruments. The appliance consists of two horizontal and parallel-acting power-bellows A and B, between which are placed the valve-box comprising the supply and exhaust chambers C, D, and E, communicating with each other and with the open air through the circular valve-throats I, J, K, and L. These throats are opened and closed by the circular, conical valves O, P, Q, and R, all of which are screwed and held in their proper relative positions on the horizontal valve-stem S. This valve-stem is actuated by the square M, the outer arm of which is moved by the draw-stop trace N, connected with the draw-stop knob in the distant console. The central chamber C is constantly charged with compressed air while the Organ is being used, and is common to all the motors placed on the valve-box; while the lateral chambers D and E are partitioned off so as to be confined to each motor. The chamber D communicates with the lower power-bellows B through the opening F, and the other chamber E

communicates with the upper power-bellows A through the opening G. The two power-bellows are connected externally by means of four strong linen tapes fastened to their movable boards, by means of which one bellows is collapsed while the other is expanded, assuming the relative positions indicated in the Longitudinal Section. These tapes are indicated at Z Z. The movable board of the upper bellows A is linked to the lever action of the appliance by the vertical rods T and U. These rods engage the rocking levers V and X, which form a parallel motion through the agency of the central link H. Y is a horizontal and W a vertical acting trace, either of which is connected with the wind-chest slider by any simple and convenient means. When the wind-chest is large and divided, a trace from each of the rocking levers V and X may operate simultaneously the sliders of the two divisions.

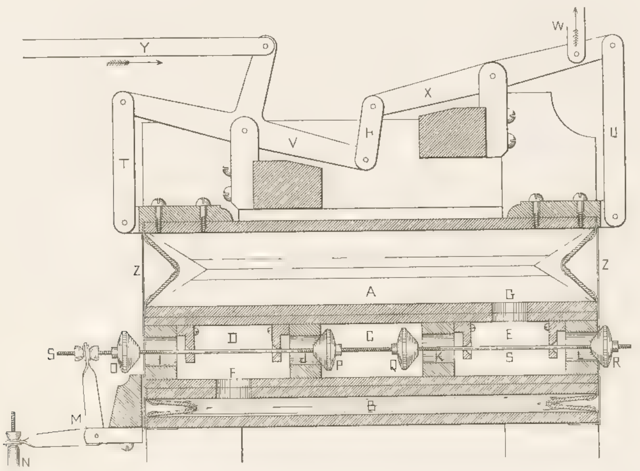


Fig. CCXXVIII.

The action of the appliance is as follows: When the stop is drawn, the square M is so moved as to place the conical valves in the positions indicated in Fig. CCXXVIII. The compressed air passes from the central chamber C through the valve-throat K, the lateral chamber E, and the opening G, into the power-bellows A, expanding the same, and moving the traces Y and W in the directions indicated by the arrows. As the power-bellows A is filled with the compressed air, the power-bellows B is allowed to exhaust through the opening F, the lateral chamber D, and the valve-throat I, into the open air. When the draw-stop knob is pushed in, the lower arm of the square M is raised by the trace N, and the positions of the valves are reversed, placing the lower power-bellows in communication with the condensed air chamber C through the valve-throat J, the lateral chamber D, and the opening F: at the same instant, the upper power-bellows is allowed to

exhaust through the opening G, the chamber E, and the valve-throat L, into the open air. As the upper bellows is drawn down by the pull of the tapes, it actuates the levers V and X and reverses the motion of the traces Y and W, pushing in the slider of the associated wind-chest.

As the above-described pneumatic draw-stop motor has considerable work to do in moving long and tightly-fitting sliders, the power-bellows are made of considerable size, requiring them to be disposed, zig-zag fashion, in two tiers. The lever action for both tiers occupies a position immediately above the upper tier, as shown in Fig. CCXXVIII. The rods which link the power-bellows of the lower tier to the rocking levers pass between the rods connected with the bellows of the upper tier. Owing to the very small and easy motion of the valves of the motor there is no inconvenience experienced in manipulating the draw-stop knobs, which, for comfort in handling, should not draw less than 1¼ inches. This distance will provide ample leverage and allowance for any lost motion. In several important Organs constructed by M. A. Cavaillé-Coll the appliance just described is found associated with the key action pneumatic lever which we have illustrated and described on pages 248 and 249 of the present volume.

We have now to direct the reader's attention to a much simpler and equally effective form of draw-stop pneumatic motor, mechanically connected with the draw-stop knob adjoining the manual claviers, which was employed in connection with slider and pallet wind-chests by the late Messrs. Roosevelt, of New York. A Vertical Section of this appliance is given in the accompanying illustration, Fig. CCXXIX., where it is shown in close proximity to the wind-chest and directly linked to the rocking lever which operates the slider. This close position is, however, by no means necessary; for where space adjoining the wind-chest is limited it may be found necessary to locate the draw-stop motors under the wind-chest, or in some more distant place, connection with the sliders being made by a trace, trundle, and lever action. The appliance is formed of the two parallel-acting power-bellows A and B, hinged to the thick center board C, and having their movable boards D and E linked together by four rods, two of which are indicated at F and G. These rods fill the same office as the tapes do in the draw-stop motor illustrated in Fig. CCXXVIII. In the upper portion of the center board C are formed the three channels or ports H, I, and J, which open upward into the small slide-box M. The channel H conveys the high-pressure air or action-wind into the left power-bellows A; while the corresponding channel J conveys the action-wind into the right bellows B. The central port I has its lower portion communicating directly with the open air, being cut entirely across the board C, below the bottom of the valve-box. This port allows the compressed air from either power-bellows to exhaust, according to the position of the controlling slide-valve N. In Fig. CCXXIX. the expanded bellows B is on the point of exhausting. The slide-valve N has just been moved, by the trace O and the slide-bar P, into the position which places its cavity directly over, and connecting, the ports I and J; while the port H is unclosed to the compressed-air chamber M, allowing the action-wind to enter the collapsed bellows A. This bellows will immediately be expanded, collapsing the other bellows B, drawing the link Q in the direction

indicated by the arrow, moving the rocking lever R, and pushing in the wind-chest slider S. The slide-valve N works practically air-tight on a surface well black-leaded, the extent of its to-and-fro movements being determined by the small, felt-covered stops T and U, while it is held down tightly against its seat by two springs, one of which is represented at V. This valve acts exactly like the slide-valve of a steam engine, opening one supply-port and connecting the other with the exhaust-port. To draw the wind-chest slider, the trace O, connected with the draw-stop knob, is moved so as to place the slide-valve over the supply-port H

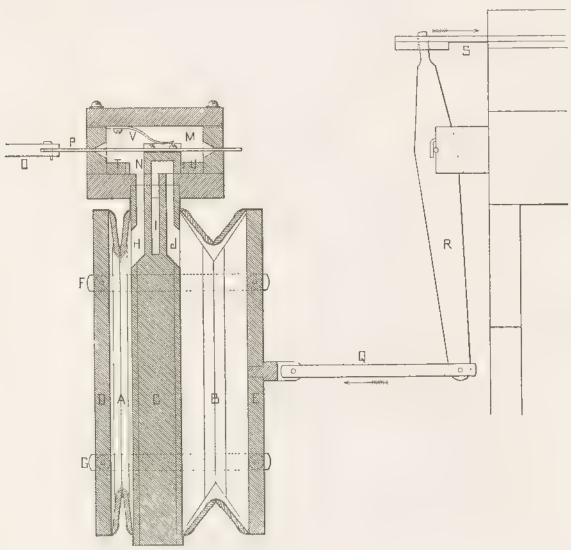


Fig. CCXXIX.

and the exhaust-port I, and to uncover the supply-port J to the compressed-air chamber M. The power-bellows B will instantly be expanded, and the slider S will be drawn outward by the linked rocking lever R, all these parts assuming the positions shown in the illustration. When the slide-valve is pushed in to the position indicated at N, the action of the appliance will be the reverse of that just described.

In Fig. CCXXIX. the slide-valve is shown as actuated by a trace connected mechanically with the draw-stop knob; but if the general action of the Organ is tubular-pneumatic, the draw-stop motors should be tubular-pneumatic also. The manner in which this can be accomplished in connection with parallel- or diagonal-acting motors will be understood from the Longitudinal Section of a valve-box given in Fig. CCXXX. Enough of the lower part of the motor is shown, above the valve-box, to clearly indicate the supply and exhaust passages leading from

the valve ports to the coupled bellows and to the open air. In all other respects the motor will be similar to that completely shown in Fig. CCXXIX., including its connection with the rocking lever which moves the slider of the wind-chest. In Fig. CCXXX. the power-bellows partly shown at A and B indicate a simpler construction than that contemplated in the Roosevelt motor; here they are formed with complete folds of strained sheepskin, simply strengthened and held in proper position by pieces of millboard glued to their inner surfaces, as indicated. Such power-bellows are sufficiently strong for the sliders of wind-chests of moderate dimensions. They have the advantage of being quickly and cheaply made. In the complete motor the movable boards D and E are linked together, and the board D is that which is connected with the rocking lever which operates the slider of the wind-chest. The channel or port J conveys the action-wind from the

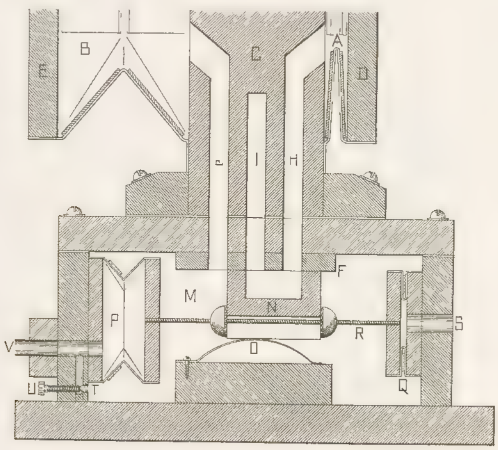


Fig. CCXXX.

compressed-air chamber M of the valve-box to the interior of the power-bellows B, while, in like manner, the port H conveys the action-wind to the interior of the power-bellows A. The port I is in direct communication with the open air, being cut across the center board C, above the top of the valve-box. These three ports are carried downward through the valve-seat F, which is a piece of boxwood or ebony, smoothly faced, and well black-leaded. The slide-valve N, also of some close-grained hardwood, is formed as shown, and held lightly against its seat by the arched spring O. The horizontal, tapped-wire R, which connects the movable boards of the pneumatics P and Q, passes through a groove in the lower part of the slide-valve, and holds the valve in proper relation to the supply- and exhaust-ports by means of the two felt-faced wood buttons, as shown. The larger pneumatic P has its interior communicating with the compressed-air chamber M through

the small feed-duct T, and also with the tubular action through the pneumatic tube V. The amount of compressed air admitted through the feed-duct is regulated by the screw U. The interior of the smaller pneumatic Q is in constant communication with the open air through the hole S. The valve-box has its compressed-air chamber M continuous, and is made sufficiently long to carry all the motors required for the associated wind-chest, each motor being firmly screwed down on the valve-box, in the manner shown.

The action of the appliance is as follows: The positions of all the parts shown in Fig. CCXXX. indicate that the stop is not drawn, and that the end of the pneumatic tube V at the console is closed. The pneumatic P, being filled with the compressed air through the feed-duct, is inoperative, while the smaller pneumatic Q is under the full pressure of the compressed air, and is, accordingly, collapsed. The corresponding position of the slide-valve places the interior of the expanded bellows B in communication with the chamber M, while the interior of the collapsed bellows A is placed in communication with the open air through the port H, the cavity in the slide-valve N, and the escape-port I. Now, when the performer draws the stop-knob, at the console, he simply uncovers the adjacent end of the pneumatic tube V. The pneumatic P immediately exhausts through the open tube, and, being larger than the pneumatic Q, collapses, expanding the smaller pneumatic, and moving the slide-valve so as to place the supply-port H in communication with the chamber M, and the other port J in communication with the open air. The power-bellows A expands, collapsing the linked bellows B, and moving the rocking lever, which, in turn, draws the slider of the wind-chest. When the performer covers the end of the pneumatic tube V by pushing in the draw-stop knob, the exhaust ceases, the pneumatic P becomes charged with the compressed air through the feed-duct T, and all the parts of the appliance resume the positions shown in our illustration.

An earlier form of draw-stop pneumatic motor, in which two parallel-acting power-bellows and the slide-valve are employed, is illustrated in Chapter XIII. of "The Organ," by Hopkins and Rimbault. In this appliance the compressed air or action-wind enters through the outer boards of the bellows, which are stationary. The wind-chest slider is connected with the central board, common to both bellows, which moves to and fro between the stationary boards as the action-wind is admitted to one or other of the bellows. The general arrangement is good, seeing that all the motors required for a wind-chest can be firmly attached to a universal compressed-air chamber extending the width of the chest. By this disposition rigidity and compactness is secured. The motors can be linked directly to the ends of the sliders or through the agency of rocking levers, as in the Roosevelt motors.

Pneumatic draw-stop motors have frequently been constructed with twin cuneiform bellows, linked together so as to be charged and exhausted simultaneously either by a slide-valve or a disc-valve action. They have also been occasionally made with a single cuneiform bellows; the slide being drawn when the bellows is charged with the action-wind, and returned by a spring when the bellows is allowed to exhaust. This latter form is reliable only when the sliders

are of moderate dimensions and move easily. In the accompanying illustration, Fig. CCXXXI., is given a Vertical Section of a draw-stop pneumatic motor in which twin and linked cuneiform bellows are introduced. Although this form of motor has commonly been commanded by a simple mechanical action, we have shown it as commanded by a tubular-pneumatic action, in which compressed air and natural exhaust are employed. Each motor comprises the two power-bellows A and B, attached to the boards C, which extend the width of the associated wind-

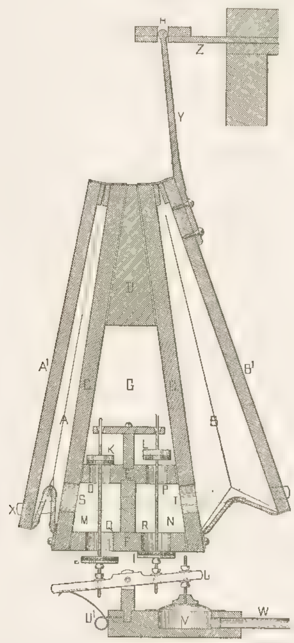


FIG. CCXXXI.

chest and form, along with the wedge piece D and the horizontal pieces E and F, the central, rigid portion of the appliance, and enclose the universal compressed-air chamber G and the special supply and exhaust chambers M and N. These special chambers are charged with action-wind from the chamber G through the valve throats O and P, and exhaust into the open air through the valve-throats Q and R. These throats are opened and closed simultaneously by the supply disc-valves K and L and the exhaust disc-valves I and J, which are carried the required distances apart on their respective stems, as shown. The openings S and T connect the interiors of the power-bellows with the special chambers M and N. The coupled disc-valves are raised and lowered by the small rocking lever

U, actuated by the diaphragm puff V and the spring U^1. The puff is charged with compressed air and subsequently exhausted through the pneumatic tube W, which is carried from the draw-stop valve- or pallet-box. The movable boards A^1 and B^1 of the bellows are linked by small, flat iron bars, which pass through the spaces between the transverse partitions of the special supply and exhaust chambers of the different motors. One of these links is indicated at X. On the movable board B^1, toward the hinged end, is fixed the iron arm Y, the upper end of which enters the slot H in the wind-chest slider Z, all as clearly detailed in the Section.

The operation of the appliance is as follows: On the puff V being inflated by compressed air from the tube W, it raises the adjoining arm of the rocking lever U and places the four disc-valves in the positions shown. The compressed air or action-wind rushes through the valve-throat P, into the chamber N, and thence through the opening T into the bellows B, which instantly expands. In expanding, it moves the arm Y and draws the slider Z: at the same time it collapses the bellows A, which exhausts through the opening S and the valve-throat Q into the open air. So long as the puff is charged with compressed air all parts of the appliance remain in the positions indicated in the Section. Now, when the draw-stop knob adjoining the claviers is pushed in by the performer, the pneumatic tube W is placed in communication with the open air, the puff V collapses, drawing down the attached arm of the lever U (assisted by the pressure of the spring U^1 on the other arm), and reversing the positions of all the disc-valves. The action-wind now rushes through the open throat O and the opening S and expands the bellows A; while the bellows B is forcibly collapsed, exhausting through the opening T, the chamber N, and the valve-throat R. The moving board B^1 and its arm Y, acting as a bent lever with its fulcrum at the hinge of the bellows, presses in the slider Z and shuts off the stop.

The appliance just described can be commanded by a slide-valve action, instead of the disc-valve arrangement as shown, the slide-valve being connected in a simple mechanical manner with the draw-stop knob: and unless the wind-chest is located at an inconvenient distance from the claviers or console, a simple mechanical motion is to be recommended. Very little power is required to move a properly-fitted slide-valve, or to actuate the rocking lever and its attached disc-valves as shown in Fig. CCXXXI.; indeed, so light would the necessary action be that a certain amount of resistance—probably by means of a friction spring—would in all likelihood be found desirable in the draw-stop knob, to give it a pleasant feeling under the hand of the performer, and to prevent its springing back when sharply drawn.

Draw-stop pneumatic motors have been made with a single power-bellows inclosed within a chamber, which chamber, along with the inclosed bellows, is alternately charged with compressed air and exhausted, either by an arrangement of disc-valves or a slide-valve movement. When the interior of the power-bellows is placed in communication with the compressed-air chamber, and the bellows-chamber is placed in communication with the open air, the power-bellows expands, moving a strong tapped-wire, which passes through a leather purse in the opposite

wall of the chamber and is screwed into a trace outside. When the bellows-chamber receives the compressed air, and the power-bellows is allowed to exhaust, the reverse motion takes place, the power-bellows instantly collapsing under the pressure on its external surface within the chamber. A motor of this description forms part of a patent taken out by Mr. Thomas Casson in 1894.* Another motor of this class, contrived by Mr. E. Holt, of Walsall, England, is illustrated and described by Mr. F. E. Robertson in his "Practical Treatise on Organ-Building."

The examples given of draw-stop actions and appliances in connection with the slider and pallet wind-chest are probably sufficient for all practical purposes. Several modified forms of those we have illustrated have been used by different organ builders in the past, but of these it is unnecessary to speak. We may, accordingly, pass on to the consideration of some of the representative forms of draw-stop actions and appliances connected with the pneumatic ventil wind-chest. The simplest form is that in which ventils or pallets are used to admit the organ-wind to the stop-chambers of the compartment wind-chest, such ventils being operated by a lever action, or by mechanically-controlled pneumatic motors. The appliance of this latter description used by the late Messrs. Roosevelt furnishes an admirable example of the class. A description of this draw-stop appliance will be found on pages 324 and 326, while Longitudinal and Transverse Sections are given, in connection with the Roosevelt wind-chest, on pages 325 and 327 of the present Volume. The disc-valves, which command the pneumatic channel communicating with the power-bellows, are shown (at V in Figs. CCXII. and CCXIII.) connected with a small rocking lever, actuated by a pull-down tracker, which is moved by the draw-stop knob adjoining the manual claviers: but these disc-valves can be operated by a simple tubular-pneumatic action, the valve-stem being attached to a small motor-bellows, after the fashion of that shown in Fig. CCXXV., or to a diaphragm-puff, such as is shown at V in Fig. CCXXXI. When the stop is not drawn, the motor-bellows or the puff is expanded with compressed air; and when the stop is drawn, it is allowed to collapse, drawing down the disc-valves, and allowing the power-bellows to exhaust into the open air.

A very efficient tubular-pneumatic draw-stop action, in which natural exhaust alone obtains in the appliance adjoining the draw-stop knob, key, or touch, is illustrated in Fig. CCXXXII. Diagram 1 is a Transverse Section of the draw-stop ventil-box, cut through the secondary pneumatic, the power-bellows, the stop-ventil, the large tube which conveys the organ-wind to the stop-chamber of the wind-chest, etc. Diagram 2 is a Transverse Section cut through the primary pneumatic and its attendant portions. Diagram 3 is an Interior View of part of the ventil-box (the front board being removed), showing the disposition of the primary and secondary pneumatics with their connecting tubes, the power-bellows, the stop-ventils, the pneumatic tubes, etc. A is the general compressed-air chamber, connected with the main reservoir by a wind-trunk, and extending the width of the wind-chest, or to such a length as may be requisite for the proper reception of

* English Letters Patent, No. 6496, dated June 2, 1894.

the necessary stop-ventils and power-bellows. B is the special chamber into which the stop-ventil C admits the organ-wind, and from which the conveyance D passes to the stop-chamber of the wind-chest. E is the power-bellows, linked to the

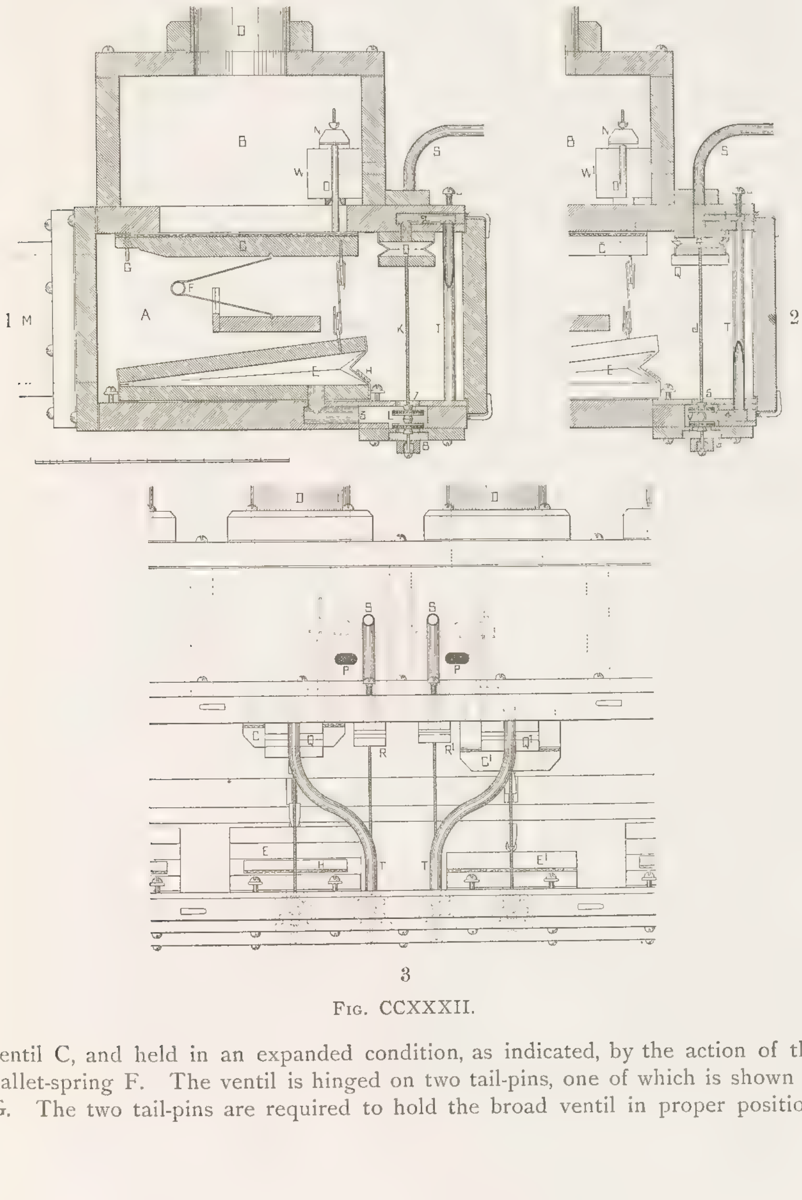


Fig. CCXXXII.

ventil C, and held in an expanded condition, as indicated, by the action of the pallet-spring F. The ventil is hinged on two tail-pins, one of which is shown at G. The two tail-pins are required to hold the broad ventil in proper position.

The ventil is faced with pallet-leather and felt in the usual manner. The folds of the power-bellows are of fine, strained sheepskin; and to prevent the bellows collapsing in a noisy manner a pad of soft felt is glued to one of its front folds at H. The bellows is held in position by four metal eyes and screws in the manner indicated. W is a block, attached to the front wall of the special chamber B, and pierced with an escape-duct, the course of which is marked by dotted lines. The external openings of two escape-ducts are shown at P in Diagram 3. The duct indicated in chamber B is opened and closed by the small pallet N, which is moved by the sticker O, the lower end of which rests on the face of the ventil C. When the ventil is drawn down by the power-bellows, the pallet N falls and closes the escape-duct; and when the ventil closes against its seat, the pallet N is raised, uncovering the escape-duct, and allowing the compressed air in the chamber B, the conveyance D, and the stop-chamber of the associated wind-chest to expend itself in the open air. Q is the secondary pneumatic, the interior of which communicates with the valve-throat of the primary pneumatic R, through the duct 2, the small conveyance T, and the duct 4. The movable board of the secondary pneumatic has the twin disc-valves L attached to it by the long valve-stem K, as shown. These valves alternately open and close the internal and external orifices of the valve-throat which communicates with the interior of the power-bellows E through the duct 3. In like manner the movable board of the primary pneumatic R has the twin disc-valves V attached to it by the pendant valve-stem J. The throat in which these valves operate has internal and external orifices, and communicates with the interior of the secondary pneumatic through the duct 4, the conveyance T, and the duct 2, as already mentioned. The interior of the primary pneumatic is in communication with the distant draw-stop appliance (adjoining the claviers) through the pneumatic tube, portion of which is shown at S. The duct immediately connected with the interior of the primary, has the small feed-duct 1 leading into it from the general compressed-air chamber A. The amount of compressed air passing through this feed-duct is regulated by the screw U. The probable position of the wind-trunk from the main reservoir is indicated at M. The trunk must be of ample width so as to furnish sufficient wind to all the stop-chambers of the wind-chest. We may point out that the escape-valve block W^1 is shown in Diagram 2 in a position different from that indicated (by dotted lines) in Diagram 3: this is done to avoid showing the block in section. It is a matter of no moment on which side of the ventil the block is located, as long as the sticker O rests properly on the face of the ventil.

From the above description and the three diagrams given in Fig. CCXXXII., the construction of the appliance can be readily understood. Its mode of action is as follows: In the Diagrams 1 and 2, and in the left half of Diagram 3, all the portions of the appliance are shown at rest, with the stop undrawn. The general chamber A is filled with the organ-wind from the main reservoir. This compressed air has found its way through the several ducts into the pneumatic tube S, the primary pneumatic R, the secondary pneumatic Q, and the power-bellows E, and instituted an inoperative state of equilibrium. Everything awaits the will of the performer seated at the claviers. Now he moves the draw-stop knob, stop-key,

or rocking touch, and in doing so simply uncovers the adjacent end of the long pneumatic tube, and allows its contents to naturally exhaust into the open air. The instant this exhaust takes place, the organ-wind in the general chamber A collapses the small primary pneumatic R and raises the disc-valves V, closing the internal orifice 5 and opening the external orifice 6. This action places the interior of the secondary pneumatic Q in communication with the open air through the duct 2, the conveyance T, and the external orifice 6. The secondary pneumatic is in turn collapsed by the pressure of the organ-wind, and its attendant disc-valves are raised, closing the internal orifice 7 and opening the external orifice 8. This action places the interior of the power-bellows E in direct communication with the open air, through the duct 3 and the orifice 8. The pressure of the organ-wind immediately collapses the power bellows, which pulls down the ventil C, admitting the organ-wind to the stop-chamber of the wind-chest, through the special chamber B and the large conveyance D. This state of the several parts alluded to is indicated in the right half of Diagram 3. The collapsed primary pneumatic is shown at R^1, the collapsed secondary at Q^1, the collapsed power-bellows at E^1, and the end of the open ventil at C^1. The respective positions of the disc-valves are indicated by dotted lines.

When the performer pushes in the draw-stop knob, releases the stop-key, or reverses the rocking touch, as the case may be, he simply closes the adjoining end of the long pneumatic tube. Instantly the tube and the primary pneumatic is filled with the compressed air by the feed-duct 1. An equilibrium being so instituted, the disc-valves V fall into the position shown. Immediately following this primary action, the original state of equilibrium and rest is established throughout the rest of the appliance, and the ventil is held against its seat by the pressure of the spring F. The illustration, CCXXXII., has been drawn by us from an actual draw-stop ventil-box lent by its inventor, Mr. Philipp Wirsching, Organ Builder, of Salem, Ohio.

The appliance just described, along with the Roosevelt appliance illustrated in Figs. CCXII. and CCXIII., practically cover the subject of the pneumatic draw-stop ventil-box through which wind is admitted to the stop-chambers of the compartment wind-chest. Other treatments certainly obtain, but they vary only in the disposition of the necessary parts, and present no advantages over those we illustrate and describe. A purely mechanical draw-stop ventil appliance, in connection with a non-pneumatic compartment wind-chest, is illustrated in Fig. CXCIII., and described on pages 275 and 276 of Chapter XXVII. In compartment wind-chests in which the stop-chambers are constantly charged with the organ-wind while the instrument is in use, a widely different class of draw-stop action is called for. It is only necessary to refer the reader to the example presented by the compartment wind-chest, illustrated in Fig. CCXXI., and fully described on pages 345, 346, and 348 of the preceding Chapter.

Of draw-stop actions in connection with single-chambered, or so-called universal, wind-chests three examples are described and illustrated in preceding Chapters. The first, which is purely mechanical, is shown in Fig. CXCIV., and described on pages 278 and 279 of Chapter XXVII. The German organ builders seem to have

interested themselves to a considerable extent in the formation of the single-chambered, or so-called universal, wind-chest, which involved the necessity of an internal draw-stop mechanism. The student of the art of organ-building who is interested in this branch of the subject will find two other forms of internal draw-stop mechanism illustrated on Plate XXIII. of "Die Theorie und Praxis des Orgelbaues."

The second draw-stop action, connected with the universal wind-chest, which we illustrate and describe, is that embraced in the appliance patented by Mr. Gern, Organ Builder, of London. This is shown in Fig. CCXVIII., and described on page 336. The external portion of this draw-stop action, which charges the longitudinal stop-duct with compressed air or opens it to the atmosphere, consists simply of a double disc-valve, or a small slide-valve, which alternately covers and uncovers ports connected with a compressed-air chamber and the open air, in the manner commonly met with in organ pneumatic mechanism. The third draw-stop action is that included in Sander's patented pneumatic action, which we illustrate in Fig. CCXIX., and describe on pages 338–340. This draw-stop action closely resembles Mr. Gern's, and is commanded by a similar simple disc-valve adjunct, placed outside the wind-chest, and connected with the draw-stop knob by either a light mechanical movement or a pneumatic tube, in the usual manner.

We may now leave the draw-stop action as it obtains in immediate communication or connection with the wind-chest, and direct the readers attention to those lesser portions of the action, which are located adjoining the manual claviers, and are under the immediate control of the performer.

Different opinions are held to-day by both organ builders and organists respecting the best and most convenient form for those external parts of the draw-stop action which are manipulated by the performer. A large majority of builders and organists continue to favor the retention of the good, old-fashioned draw-stop knobs; and we are free to admit that, under favorable conditions, they are to be preferred to the purely modern devices. Other builders and organists advocate the general use of the different styles of touches, which rock on a center when pushed or touched lightly by the finger; while others—fewer in number at the present time—lean toward the adoption of the so-called stop-keys, which resemble in form, and are pressed down in the same manner as, the ordinary keys of the instrument. It must be borne in mind, however, that the adoption of one or other of the above-mentioned draw-stop devices is not altogether a matter of choice, but is largely governed by the style of action which obtains in the Organ. For instance, in an instrument which has a simple, old-style draw-stop action, such as that illustrated in Fig. CCXXVI. or in Fig. CCXXVII., neither the rocking touches nor the stop-keys would be suitable: while in tubular-pneumatic or electro-pneumatic actions any one of the three devices may be adopted, the peculiar treatment and disposition of the action determining which is the most suitable. Again, the size of the Organ, or, in other words, the number of its speaking stops, couplers, and other accessories, has a good deal to do in determining the form and situation of the external draw-stop devices. It is questionable, for instance, how far the stop-key device can be conveniently carried. It is certainly very suitable for

Chamber Organs or other instruments of small dimensions, doing away with the necessity of introducing anything in the nature of draw-stop jambs, and of extending the key-case much beyond the length of the claviers. In such instruments the stop-keys can be conveniently placed in the center of the key-case, a short distance above the upper manual clavier. We find the stop-keys so located in the Haskell console, as made by the Estey Organ Company, of Brattleboro, Vermont. We shall speak at greater length on this draw-stop device farther on.

The forms and proportions of draw-stop knobs vary considerably, organ builders usually adhering to special forms unless otherwise instructed. The conditions which constitute a good knob are: First, that it shall present a surface suitable for the reception of a bold and full inscription, recording the name and size of the stop. Secondly, that it shall be so formed as to be pleasant and convenient to the fingers of the performer; and to be so it must be long rather than stumpy, and present no sharp edges to the touch. In the accompanying illustration, Fig. CCXXXIII., are given forms of draw-stop knobs of the class just alluded to.

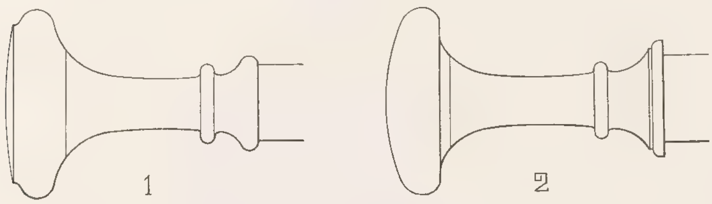


Fig. CCXXXIII.

Such knobs should be of solid ivory, or have solid ivory heads, securely joined to shanks of ebony or some hard, rich-colored wood. Knobs of this latter description are represented, the lines immediately behind their heads indicating where the ivory joins the ebony shanks. For Church and Concert-room Organs, knobs of this artistic and practical character should not be less than 1¾ inches or more than 2 inches in length, having heads 1⅜ inches in diameter. For Chamber Organs, in which extreme elegance should characterize every detail, the knobs should be smaller and made of solid ivory and attached to polished ebony rods. In fine work the rods should work in turned collars lined with scarlet cloth. Probably the most inartistic and unsightly draw-stop knob introduced in modern Organs is the oblique-faced, bulbous-headed one so commonly used by the American organ-builders. That the oblique face is very convenient, when the knob occupies a position where a straight face would be seen by the performer with some difficulty, we do not deny; but there can be no necessity to use the oblique-faced knobs in segmental or oblique stop-jambs. We have not met with a single instance of the introduction of these ugly knobs in an English Organ. German organ builders, however, appear to be using oblique-faced knobs; for glancing at a "price list" issued by a prominent German manufacturer of organ fittings, small work, etc., we

see four illustrations of oblique-faced knobs, which can only be described as "fearfully and wonderfully made."

Draw-stop knobs of various forms are commonly made of choice hardwoods, having circular name-plates of ivory, celluloid, or porcelain inserted in their faces. When properly shaped and proportioned, such knobs have a handsome appearance. They lend themselves to a practical system of coloring, by the adoption of woods of different and contrasting tints, whereby all the stops belonging to the several divisions of the Organ can be readily distinguished. The woods available for this purpose are rosewood, snakewood, tulipwood, logwood, laburnum, satinwood, boxwood, and the black, green, and yellow ebonies. All these woods turn well, and receive a high finish and polish. In the best work the name plates should be of ivory. The names of the stops and their pitches should in all cases be boldly rendered, either in block letters or plain Gothic text. When the latter is adopted, the initial or capital letters should be in red and the small letters and numbers in black. This treatment has a very pleasing effect, and is to be especially recommended for the Chamber Organ, in which every external feature should be rich, refined, and artistic.

In Fig. CCXXVI. is shown the manner in which a draw-stop knob is connected directly with the ordinary mechanical action; so it only remains for us to briefly touch on the pneumatic appliances with which the draw-stop knobs are associated. These appliances are of three classes. The first is that in which a natural exhaust is alone provided for, and which, accordingly, is connected with the distant draw-stop motor or ventil-box by a single pneumatic tube. The second appliance is that in which compressed air and a natural exhaust is provided in connection with a single pneumatic tube. The third is that in which two ("on" and "off") pneumatic tubes are used, each being alternately charged with compressed

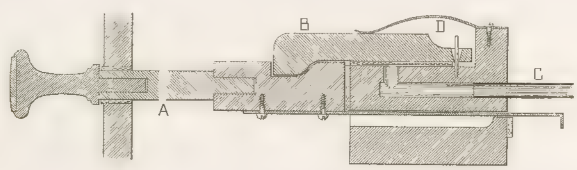


Fig. CCXXXIV.

air and allowed to exhaust naturally into the open air. This last form is employed by certain English organ builders, but is neither necessary nor to be recommended. No properly designed pneumatic draw-stop action need have more than a single pneumatic tube, for natural exhaust alone, or supply and exhaust alternating, according to the construction of the draw-stop motor or ventil-box.

In Fig. CCXXXIV. is given an example of the draw-stop appliance of the first class above outlined. All that the draw-stop knob and rod A have to do when moved by the hand is to operate the small pallet B so as to uncover or cover the

duct which is practically a continuation of the pneumatic tube C. The stop is represented as undrawn and the pallet in its closed position. It is obvious that when the stop-knob is drawn, the end of the pallet B will be raised by the rear part of the rod A, and will uncover the orifice of the pneumatic tube C. Now, if the reader will, in imagination, carry this pneumatic tube ten or twenty feet and join it to the pneumatic tube S, shown in Diagram 2, Fig. CCXXXII., he will be able to realize the complete draw-stop action, and trace its every motion from the moment the performer touches the stop-knob until the ventil opens and admits the organ-wind into the stop-chamber of the wind-chest—an operation occupying no appreciable lapse of time.

The manner in which the appliance of the second class may be constructed varies according to circumstances, but in all cases it can be extremely simple. As highly compressed air or the ordinary organ-wind has to be sent through the single pneumatic tube, alternating with natural exhaust, a compressed-air chamber has to be provided adjoining the draw-stop knob, furnished with either double disc-valves, after the fashion of the valve-boxes illustrated in Fig. CXCV., page 290, or with a simple slide-valve action as here given in Fig. CCXXXV. The latter will, in the generality of direct actions, be found most convenient. A is the compressed-air

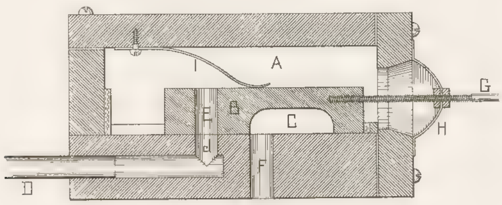


Fig. CCXXXV.

chamber containing the slide-valve B. This valve has the hole E bored through it for the purpose of admitting the compressed air into the pneumatic tube D; and is hollowed out at C for the purpose of connecting the port of the pneumatic tube with the exhaust-port F when the draw-stop knob, which is connected with the wire G, is pushed in. In the Transverse Section given in Fig. CCXXXV. the slide-valve is shown in the position it is supposed to occupy when the stop-knob is drawn; but this position obtains only when the "on" action requires compressed air. When the "off" action requires compressed air, and the natural exhaust brings the stop on, the positions of the supply- and exhaust-ports and the corresponding parts of the slide-valve must be the reverse of those indicated. The slide-valve B is held firmly against its seat by the spring I, and is actuated by the wire G, which passes through the leather purse H. The chamber A is general to all the slide-valves that may be placed therein. If the draw-stop rod is directly connected with the wire G, the length of the motion desired for the draw-stop knob will have to be provided for by placing the supply- and exhaust-ports J and

F the necessary distance apart, and forming a slide-valve to accord. On the other hand, should the wire G be connected with the draw-stop rod by means of a rocking lever, the respective movements of the slide-valve and the draw-stop knob can be easily adjusted in the manner of pivoting the lever. When the rocking lever is pivoted between the wire G and the draw-stop rod, the slide-valve will move in the direction opposite to that of the draw-stop knob, and, accordingly, the supply- and exhaust-ports must occupy positions the reverse of those shown in Fig. CCXXXV. The illustration given is sufficient to show the principle on which the slide-valve action is constructed in connection with the single pneumatic tube.

A slider action is preferred by some organ builders; and when carefully made it is quite as efficacious as the slide-valve action above described. The ordinary form of the slider action is shown in the accompanying illustration, Fig. CCXXXVI., which is a Longitudinal Section of the appliance. A is the compressed-air chamber which communicates, through the duct B, with the pneumatic tube C when the slider E is in the drawn position indicated. When the slider is pushed by the

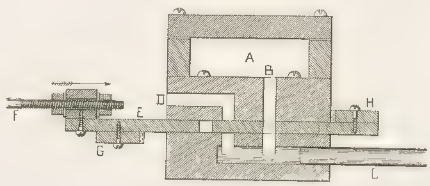


Fig. CCXXXVI.

draw-stop knob attached to the rod F, in the direction shown by the arrow, the compressed air is cut off from the pneumatic tube C, and the tube is allowed to exhaust into the open air through the duct D. The two perforations in the slider allow this change to be promptly made. The motion of the slider is adjusted by the two felt-covered blocks G and H.

The appliance of the third class, in which two pneumatic tubes are required for the "on" and "off" actions, may be conveniently constructed with a slide-valve in the manner shown in Fig. CCXXXVII. A is the compressed-air chamber, in which is located the long slide-valve B, perforated at C and D for the passage of the compressed air to the pneumatic tubes E and F through their respective supply-ports, and hollowed at G for exhausting the pneumatic tubes through the exhaust-port H. The slide-valve is held firmly against its seat by the spring I, and is connected with the draw-stop knob by the wire J, which passes air-tight through the leather purse K. The position of the slide-valve shown in the illustration indicates that the stop is drawn, the perforation C communicating with the "on" tube E, while the "off" tube F is exhausting through the central port H. The required motion of this slide-valve is so small that it is necessary to introduce a lever of some convenient form between the wire J and the draw-stop rod, so as to give the draw-stop knob a comfortable motion under the hand. An appliance

similar to that just described has been used by Messrs. Abbott and Smith, Organ Builders, of Leeds; and the same firm also uses a compound disc-valve appliance in connection with the double pneumatic tubes. The four disc-valves are carried on a single valve-stem, which is attached to a lever arm actuated by the draw-stop rod. The to-and-fro motion of the disc-valves alternately opens one pneumatic tube to the compressed-air chamber and the other to the open air. The valve-throats and the ducts leading to the two pneumatic tubes are formed in the side walls of the compressed-air chamber, directly opposite to each other.

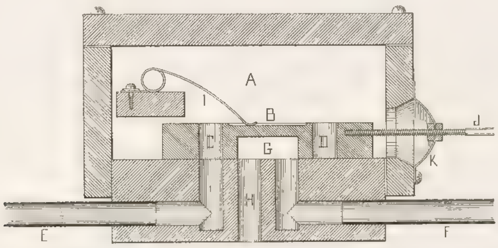


Fig. CCXXXVII.

There are several forms of stop-touches which are actuated by a slight pressure of the finger, and these are preferred by certain organ builders and organists to the ordinary stop-knobs. In some Organs both touches and knobs are introduced, the former being used for the couplers while the knobs command the speaking stops. When this arrangement obtains, the touches are usually placed in a row

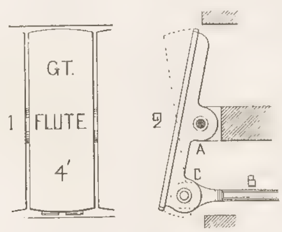


Fig. CCXXXVIII.

above the upper clavier, as in the important console illustrated in Plate VI. In the electric consoles constructed by certain organ builders touches are alone used, and they are invariably arranged in a row or rows above the highest clavier so as to be in the full view of the performer. The touch most frequently used is in the form of a small oblong tablet of ivory or (in inferior work) celluloid, pivoted horizontally in the center so as to form a rocking lever, the stop-rod being linked

to it behind and close to one of its ends. These have been termed "domino" touches or keys. The normal form of the rocking touch is shown in the accompanying illustration, Fig. CCXXXVIII. Diagram 1 is a Front View and Diagram 2 a Side View, full size. The dimensions of these tablets vary, but they should not exceed 2 inches in length by ⅞ inch in width. The touch is pivoted at A, and the stop-rod B is attached to it at C. As the to-and-fro motion of the rod is necessarily small, it has to be connected with a slider appliance requiring no greater motion, or with a pallet or slide-valve appliance through the intervention of a lever arm or rocking lever. In Fig. CCXXXIX. is shown another form of touch, which appears to be a transition from the rocking tablet to the stop-key, presenting something of both. It may be appropriately designated the L-touch. Examples are to be found in the Concert Organ in the Battersea Polytechnic, London, constructed by the late firm of Beale and Thynne. These touches are placed immedi-

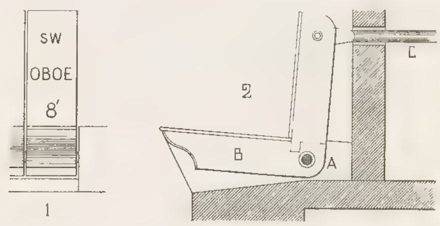


Fig. CCXXXIX.

ately above the upper clavier, and are directly connected with a slider appliance similar to that illustrated in Fig. CCXXXVI. Diagram 1, in Fig. CCXXXIX., is a Front View of one of these L-touches; and a Side View of the same touch is given in Diagram 2. The touch is formed of light-colored hardwood plated with ivory on its exposed surfaces. It is pivoted on a strong wire at A; and on its projecting arm B being pressed down by the finger, it draws the stop-rod C and actuates the slider of the draw-stop appliance to which it is attached.

In the year 1898, Mr. Charles Frederick Brindley, Organ Builder, of Sheffield, patented an early form of stop-key,* which he describes in his Patent Specification thus:

"My invention relates to an improved system of 'registration' in Organs, and to the means by which such system is carried into practice, the object being to render the action easy and perfectly natural to the hands of the performer, and thereby capable of rapid transition.

"The means by which I carry out my invention is as follows: Connected at their back ends with the stop-valves, are a set of keys preferably black, and pivoted somewhere between their ends, which, when pressed down, shut off or negative the registration. A little above

* "Improvements relating to Stop Mechanism of Organs." English Letters Patent, No. 20,264, dated Aug. 6, 1898.

these black (or negative) keys are a set of shorter white (or positive) keys, pivoted at their back ends, and between each white key and the black key under it I place a short sticker, resting upon the black key, and supporting the white one, the sticker being located somewhere between the pivot of each key.

"When a white or positive key is pressed down by the performer, it transmits its motion through the sticker to the black or negative key at the back of its pivot, and raises the front end to meet that of the depressed white key, and at the same time operating the stop-valve. When the black key is pressed down it closes the stop-valve, raises the white key, and shuts off or negatives the registration."

The above description will be clearly understood on reference to the accompanying illustration, Fig. CCXL., which is a Side View of a positive and a negative key, pivoted and connected in the manner stated. This illustration shows the alternative treatment represented in the Patent Specification, which properly places the positive key, plated with ivory, under the negative key, fronted with ebony.

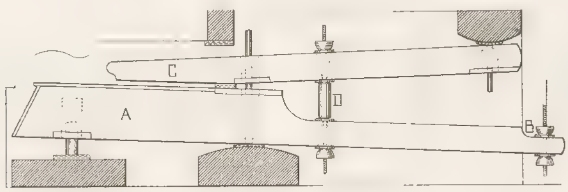


Fig. CCXL.

When this treatment is adopted, the stop-keys are intended to occupy a central position directly over the upper manual clavier; while the other treatment described in the preamble of the Patent Specification is intended for stop-keys occupying positions at the ends of the claviers.

A is the white, positive key, plated with ivory, and bearing the name of the stop on its sloping front. The pneumatic stop-valve is connected with this key at B. C is the black, negative key, coupled to the positive key by the short sticker and tapped-wires at D. When the white key is depressed by the finger, the black key is elevated; and when the black key is subsequently depressed (in the process of shutting off the corresponding stop), the white key is raised in front to the position indicated in Fig. CCXL. The white keys would properly be about ⅞ inch in width; while the black keys, placed in a central position, would not have to be more than ½ inch in width. This seems to be the first true stop-key device introduced in the Organ, and we have much pleasure in recording it in these pages.

We have now to direct attention to the stop-keys as introduced in the Organs constructed by other builders, and notably in the smaller Organs constructed by the Estey Organ Company. These stop-keys, properly so-called, are made in a similar manner to the natural and sharp keys of the manual claviers, and are conveniently placed in a central position immediately above the upper clavier, and,

accordingly, within easy reach of the performer's fingers. The ivory-plated keys are about 1 inch in width and 3 inches in length, while the ebony keys, somewhat narrower than the manual sharp keys, are about 1½ inches in length. There is a black key inserted toward the right side of each white key, and its office is to release its associated white or stop-key from its depressed position incident on drawing its stop. In the accompanying illustration, Fig. CCXLI., are given a Front and a Top View of a few stop-keys, as above described. The fronts of the white keys are finished square, their ivory platings (celluloid in inferior work) being in-

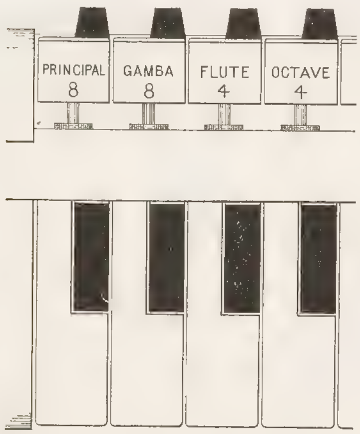


Fig. CCXLI.

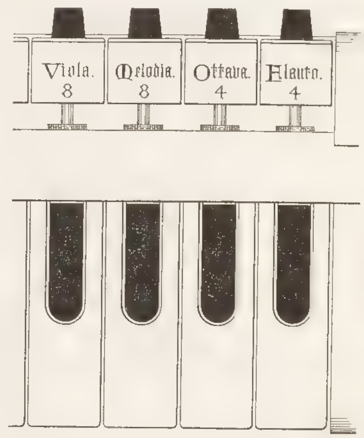


Fig. CCXLII.

scribed with the names of the stops which the keys command. After the stop-key is depressed and its associated stop drawn, it is instantly released and its stop silenced on depressing the attendant black key. The white keys are simply small rocking levers, which, when depressed by the fingers, uncover the open ends of the pneumatic tubes, which extend to the wind-chests and coupling appliances; and when so depressed they are automatically held in that position by small spring-catches. When the black keys are pressed down, they operate on the catches, and allow the stop-keys to return to their original position. The tails of the stop-keys may be faced with felt and leather and rest on the tube-block in which are the orifices of the pneumatic tubes; or they may act on independent pallets hinged to the tube-block. The keys may also be made, by a simple action, to operate a slider appliance.

We think the general appearance of the stop-keys would be greatly improved if the black releasing-keys were placed in a central position instead of to one side of the draw-stop keys. In this case they would move in slots cut in the latter. The disposition just suggested is shown in Fig. CCXLII. It certainly prevents

any uncertainty as to which white stop-key the black releasing-key belongs. We are also of opinion that if the fronts of the white keys were inclined, or made slightly concave, in a forward direction they would have a better appearance, and their inscriptions would be more easily seen by the performer while seated at the claviers.

There is another form of draw-stop touch which has recently been introduced by a prominent American organ-building firm; which touch has, in our estimation, absolutely nothing to recommend it. This touch is in the shape of a short, rounded plate, properly of ivory, hanging forward and sloping downward from the top edge of the board which rises vertically above the upper clavier. It is pivoted close to the edge of the board, and hangs entirely free in front of the board. A number of such touches, arranged side by side, strongly resembles a row of gigantic teeth. When one of these touches is pressed downward to a greater angle its attendant stop is drawn. There is no objection to this motion; but when the stop has to be silenced, the touch has to be flipped upward by the finger—an inelegant and inconvenient operation, and one at variance with all other styles of organ action and control. We hope this form of draw-stop touch will not come into anything like general use even in the works of its inventors. It is novel; but novelty is only meritorious when it heralds an advance or improvement. This fact should never be forgotten by the organ builder.

CHAPTER XXXI.

THE PNEUMATIC COUPLERS.

THE several systems or forms of pneumatic coupling that have been introduced by different organ builders are, as a rule, extremely simple. All that the most effective form is called upon to do is to provide means whereby the pneumatic tubes leading from the valve-box or pallet appliance attached to any clavier—manual or pedal—to its own and other divisions of the Organ can, at the will of the performer, be brought into operation simultaneously. For instance, when the Swell to Great coupler is drawn, it is only necessary that the tubes leading from the Great Organ valve-box or pallet appliance (either direct or through some intermediate appliance) to both the Great and Swell wind-chests be opened to the external air, or charged with compressed air, as the case may be, simultaneously on the depression of the Great Organ keys. Accordingly, all that the Swell to Great coupling action, directly operated by its draw-knob or touch, has to do is to open and close the ports or outlets of the Swell Organ pneumatic tubes in the Great Organ valve-box or in any coupling appliance provided for the purpose.

In the present Chapter it is only necessary to describe and illustrate representative systems, which practically display all the principles of construction to be found in the most satisfactory pneumatic coupling actions. We may properly start with the early form patented by Mr. Robert Hunter, Organ Builder, of London, in the year 1885.* In the preamble of the Patent Specification the inventor says:

"This Invention relates to an improved method of coupling notes on an Organ, which consists chiefly in the employment of pneumatic tubes instead of levers, such as have heretofore been employed, the object being to enable the performer to depress the keys with a uniform pressure or touch.

* "Improvements in the Manufacture of Wind Organs." English Letters Patent, No. 6946, dated June 8, 1885.

"For this purpose I divide the 'Swell' air chamber into as many air-tight compartments or chambers as there are keys or notes on the Organ, the partitions being formed by metal plates fitting in grooves or channels in the back and front of the chamber.

"Over and behind the keyboard are placed two or more sound-boards or chambers into which the coupling tubes are inserted at one end, the other ends of the tubes communicating with the Swell chamber—The sound-boards are provided with pallets and slides to shut couplers on and off, the slides operating in a similar manner to ordinary slide-valves."

The accompanying illustration, Fig. CCXLIII., which is a Transverse Section through the several portions of the action,* and the following description will enable the reader to understand the construction and operation of this primitive pneumatic coupler. A is the tail of the Great Organ key, and B is the tail of the corresponding key of the Swell Organ. The former, through the instrumentality of its sticker and backfall, operates the pallet C within the compressed-air chamber D; while the Swell key, through the movement of its backfall, operates the pallet E within the compressed-air chamber F, in the manner shown. The pallets C and E command their respective grooves G and H, formed in the upper portions of the key pallet-boxes M and N, which are constructed, after the fashion of the ordinary wind-chest, with tables, sliders, bearers, and upper-boards. The perforations which extend from the grooves upward through the tables, sliders, and upper-boards, receive the lower ends of the coupling pneumatic tubes K, L, O, P, Q, and R. The remaining two tubes I and J are those belonging to the direct action of the Great and Swell Organs. S is the portion designated in the Specification the "Swell air chamber," but which would be more expressively called the coupling- or mixing-bar. This portion of the general appliance is divided by thin metal partitions into as many vertical channels as there are notes in the manual claviers. T is the Great Organ coupling-bar, constructed in the same manner as that of the Swell Organ. U is the tube which leads from the Great Organ coupling-bar to the Great Organ wind-chest; and V is the tube which leads from the Swell Organ coupling-bar to the Swell Organ wind-chest. In the channel T^1 are the two small flap-valves 1 and 2; and in the longer channel S^1 are the six flap-valves 3, 4, 5, 6, 7, and 8, guarding the orifices of the respective pneumatic tubes. While eight tubes are shown as communicating with the vertical channels S^1 and T^1, it must be understood that six of them (shown broken) are not continuations of the corresponding tubes which rise from the key pallet-boxes M and N. The tube K, which belongs to the octave coupler acting on the Great Organ, enters the twelfth channel above the channel shown at T^1. The tube O, which belongs to the Swell to Great octave coupler, enters the twelfth channel above the channel S^1, while the tube P, which belongs to the Swell to Great sub coupler, enters the twelfth channel below the channel S^1. In like manner, the tube R, which belongs to the Swell octave coupler on itself, enters the twelfth channel above the channel S^1; while the tube Q, which belongs to the Swell sub coupler on itself, enters the twelfth chamber below the channel S^1. The channels S^1 and T^1 may be understood to belong to the middle c^1 keys of the Great and Swell claviers, and, accordingly, will

* Somewhat improved from the diagram given in the Patent Specification, unaccompanied by a scale.

receive the full complement of tubes from the unison, sub, and octave grooves of the key pallet-boxes M and N, as indicated. All the pneumatic tubes which belong to the unison, octave, and sub couplers have their lower orifices opened and closed by the sliders, which are mechanically moved by the coupler draw-knobs; while their upper orifices in the coupling-bars S and T are opened and closed by the small flap-valves 2, 4, 5, 6, 7, and 8. The direct Great and Swell tubes I and J

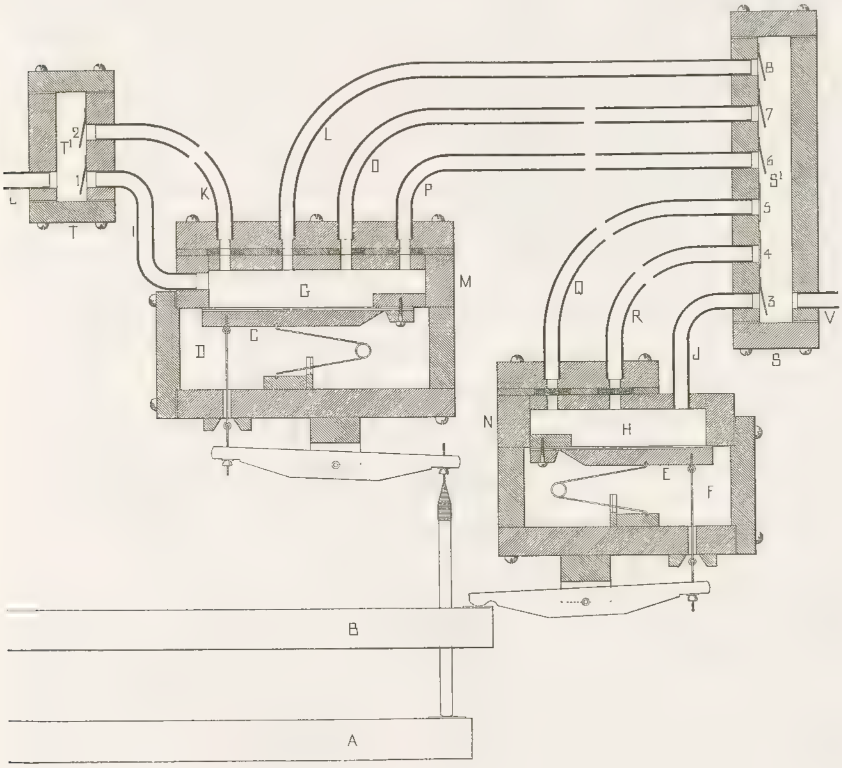


Fig. CCXLIII.

are also, for obvious reasons, provided with the flap-valves 1 and 3. In the Great Organ pallet-box M all the sliders are indicated in the "on" position, leaving a free communication between the groove G and all the four coupling tubes. In the Swell Organ pallet-box N the sliders are indicated in the "off" position, closing all communication between the groove H and the coupling tubes Q and R.

The operation of this coupling action is so simple and obvious as to call for no special description; but so as not to leave any reader in doubt, we may just point

out that on the depression of the Swell Organ key B, the pallet E is drawn down, admitting compressed air from the chamber F into the groove H, and thence through the tube J into the vertical channel S^1, pushing open the flap-valve 3, and instantly closing all the other flap-valves in the channel. Under these circumstances, the only outlet for the compressed air is through the tube V, which extends to the pneumatic motor or appliance attached to the Swell Organ wind-chest. This is the direct unison action belonging to the key which is depressed. Now, if the slider of the sub coupling tube Q is drawn so as to connect it with the groove H, on the depression of the key B compressed air will be admitted into the channel S^1, as above described, and at the same instant compressed air will be admitted through the tube Q, into another channel—the twelfth in number below the channel S^1—causing another motor to operate at the Swell Organ wind-chest. The result will be that in addition to the pipes strictly belonging to the depressed key, the pipes belonging to the key an octave below will speak simultaneously. This sub coupling will obtain on every key from tenor C to the top of the clavier. All the other coupling tubes will act in a similar fashion either in the octave above or below. It will be observed that in this early form of pneumatic coupling action compressed air is alone provided for in the key pallet-boxes, and that there is a total absence of means in them for exhausting the pneumatic tubes on the release of the manual keys. This necessary exhaust must, accordingly, take place in the pneumatic appliance attached to the wind-chest, but the Patent Specification contains no allusion to anything beyond the coupling action.

In the accompanying illustration, Fig. CCXLIV., is given a Transverse Section of a very simple and efficient Swell to Great coupling action, as constructed by Mr. Ernest M. Skinner, Organ Builder, of Boston, Mass.; and we give this largely on account of the ingenious and extremely sensitive wind-chest pneumatic station with which it is associated.* A is the key pallet-box belonging to the Great Organ, and B is the key pallet-box belonging to the Swell Organ. These are constantly charged with the action-wind while the Organ is in use. In both boxes a narrow pallet is provided for each key of their respective claviers. The pallets are indicated at C and D, connected with the key tails in the direct manner shown, and covering the channels E and F. These channels communicate with the open air through the valve-throats I and J, which are opened and closed by the small disc-valves G and H, suspended from the pallets C and D, and fitted with spiral, compensating springs, as indicated. The other end of the channel E communicates with the pneumatic tube 4, which extends to the Great Organ wind-chest pneumatic; and also with the tube 2, which leads to the coupling-bar K. In like manner, the end of the channel F communicates with the duct 3, which passes down the coupling-bar into the cell 1, directly opposite the duct, which is practically a continuation of the tube 2. Between the openings of these two ducts hangs the flap- or check-valve indicated by the single dark line. From the bottom of the cell 1 issues the pneumatic tube 5, which extends to the Swell Organ wind-chest pneumatic. The operation of the coupler is commanded by the longitudinal slide L,

* Our illustration is copied from a full-size drawing kindly furnished by Mr. Ernest M. Skinner.

which opens and closes the duct belonging to the tube 2. When the coupler is not drawn, all communication between the channel E and the cell 1 is cut off. On

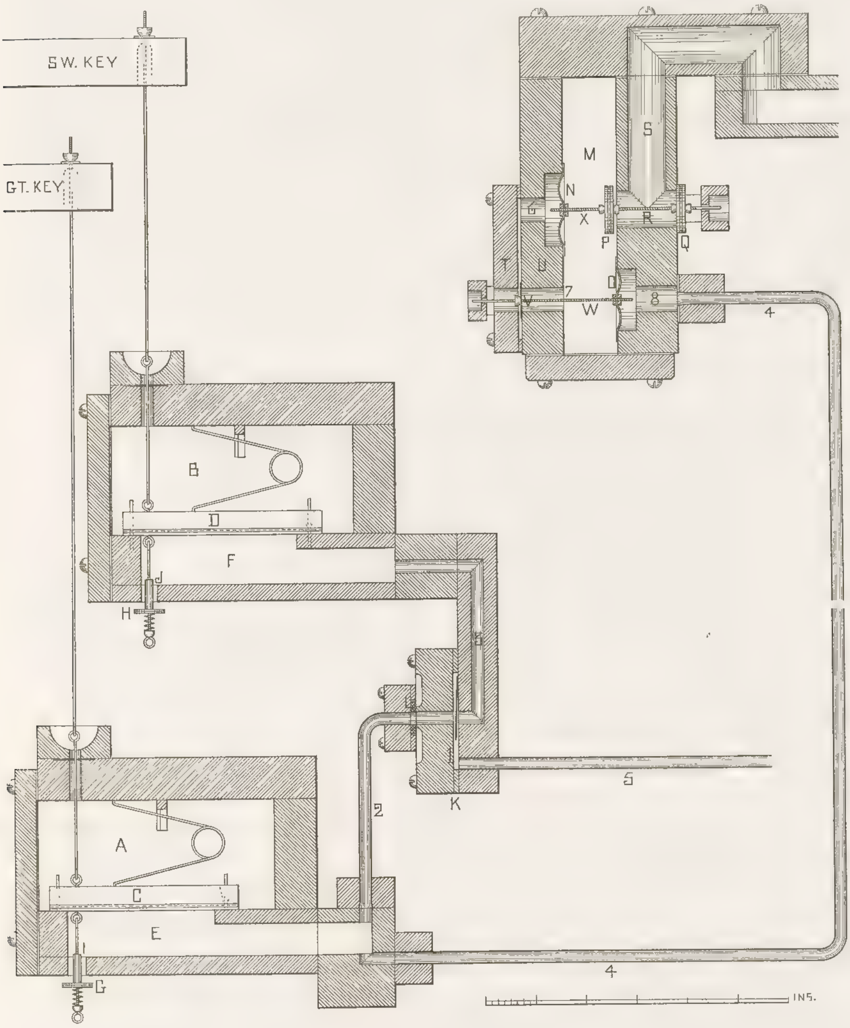


Fig. CCXLIV.

the Great Organ key being depressed, the action-wind in the box A enters the channel E and the direct-action pneumatic tube 4; and on the Swell Organ key

being depressed, the action-wind in the box B enters the channel F, and passes thence, through the duct 3, the cell 1, and the tube 5, to the Swell Organ wind-chest pneumatic station. Now, when the slide L of the coupling bar is drawn, and the Great Organ key is depressed, the action-wind enters (in addition to the direct-action tube 4) the coupling-tube 2, closes the check-valve against the orifice of the duct 3, passes down the cell 1, and, finally, along the direct-action tube 5, to the Swell Organ wind-chest pneumatic. The coupling is complete, and both the Great and Swell pipe-work responds to the depression of the Great Organ key. When the key is released, both the tubes 4 and 5 exhaust through one or both of the valve-throats. When the slide L is not drawn, a transverse groove on its side next the coupling-bar K communicates with the two small grooves indicated. This arrangement is necessary to secure the certain and immediate exhaust of the tube 5 when the Swell Organ key is released by the finger. The exhaust is certain whatever position the check-valve is in, for it is impossible for it to close the orifices on both sides at once.

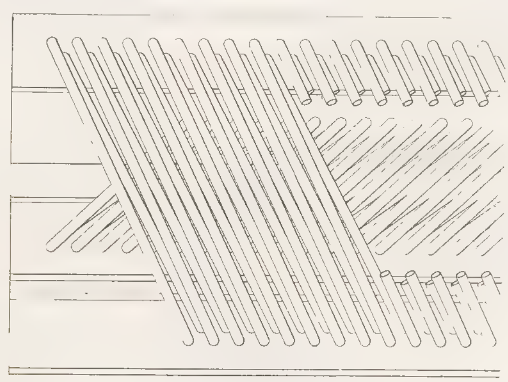


Fig. CCXLV.

From the above description, aided by the accompanying illustration, it is easy to realize that by the simple addition of similar parts in an adequate coupling-bar, and a diagonal disposition of coupling-tubes—after the usual manner indicated in Fig. CCXLV.—both Swell to Great sub and octave couplers can be introduced.

In the upper part of Fig. CCXLIV. is given a Transverse Section of the very efficient wind-chest pneumatic station above alluded to. We have a working model before us as we write, and can, accordingly, vouch for the marvelous sensitiveness and repetition of the appliance. In these respects it is the most satisfactory pneumatic station known to us. It may be described as follows: M is the general chamber, charged with organ-wind at all times while the Organ is being used. O is the diaphragm of the primary pneumatic, and N is the diaphragm of the secondary pneumatic. The former has the valve-stem W attached to it, carry-

ing the disc-valve V in the manner indicated. This valve is a metallic disc of the thickness of an ordinary sheet of paper, or about $\frac{1}{50}$ inch; and the extent of its movement, within the cell formed by a perforated layer of six-sheet Bristol board, placed between the side U of the general chamber and the applied piece T, is also about $\frac{1}{50}$ inch. Accordingly, the cell formed by the perforated cardboard is only about $\frac{1}{25}$ inch: it communicates at top with the interior of the secondary pneumatic, through the duct 6; and at bottom with the valve-throat 7. The diaphragm N carries one end of the valve-stem X, on which are placed the twin disc-valves P and Q, commanding both ends of the valve-throat R, as clearly shown. This valve-throat communicates with the pneumatic channel S, which extends transversely under the compartments or stop-chambers of the associated wind-chest, and into which the ducts from the several pipe pneumatics enter, in the manner previously described in the Chapter on the Pneumatic Ventil Wind-chest. The pneumatic tube 4, from the Great Organ key pallet-box, communicates with the interior of the primary pneumatic, through the duct 8. All the other details of the appliance are so clearly shown as to require no description.

The action of the appliance is extremely simple. In the Section all the movable parts are shown in their relative positions when the corresponding manual key remains untouched. Under such a condition, the interiors of both the primary and secondary pneumatics are in communication with the open air, and the wind-chest pneumatic channel S is charged with the action-wind from the chamber A, the disc-valve P being drawn inward by the pressure of the wind on the inner surface of the diaphragm N; while all communication with the open air is shut off by the tightly closed disc-valve Q, as shown. Now, when the key is depressed, wind is admitted from the Great Organ key valve-box A into the pneumatic tube 4, and thence into the interior of the primary pneumatic. An equilibrium being established on both sides of the diaphragm O, the metallic disc-valve V is driven against the orifice in the board T, and communication is made between the chamber A and the interior of the secondary pneumatic, establishing an equilibrium on both sides of the diaphragm N. Pressure is instantly exercised on the disc-valve Q, blowing it outward, and closing the disc-valve P. The wind-chest pneumatic channel S now exhausts through the open valve-throat R, and the pipes planted on the wind-chest speak by the means provided. When the manual key is released, the interior of the primary pneumatic exhausts through the tube 4, and its diaphragm and metallic valve assume the positions shown in the Section; the interior of the secondary pneumatic likewise exhausts, and its diaphragm and the connected disc-valves return to the positions indicated; and, lastly, the pneumatic channel S becomes charged with action-wind, bringing every mechanical part, as above described, to the original state of rest.*

A pneumatic coupling action, constructed on a principle essentially different from those which obtain in the other actions described in the present Chapter, has been recently patented by Mr. William E. Haskell, and assigned to the Estey

* It may be considered that the description of this ingenious pneumatic station strictly belongs to Chapter XXIX.; but as the appliance is so directly associated by its inventor's coupling action we thought it expedient to describe and illustrate them together.

Organ Company, of Brattleboro, Vermont.* In the preamble of the Patent Specification the inventor says:

"The object of the present invention is to provide a pneumatic coupler for Pipe or Reed Organs of improved and simplified construction and mode of operation. . . .

"I have illustrated [by drawings appended to the Specification] my invention as embodied in an Organ in which the various wind-chests or chambers are supplied with air under pressure; but it is to be understood that my invention is not limited to this type of Organ, but is equally capable of embodiment in an Organ in which the wind-chests or chambers are partially exhausted of air. It is also to be understood that my invention may be embodied in an automatic Organ, the automatically-operating mechanical devices of such an Organ being the equivalents, so far as the present invention is concerned, of the manually-operated keys of the Organ.

"An Organ embodying my invention is provided with channels, hereinafter referred to as 'sounding-channels,' in which the air-pressure is varied to cause the sounding devices connected therewith to speak, with wind-chests or chambers in which a constant pressure is maintained, hereinafter referred to as 'constant-pressure' chambers, and with valves for controlling the pressure in the sounding-channels.

"In accordance with my invention a pneumatic located in a constant-pressure chamber is provided for actuating the valve of a sounding-channel, and a channel is provided connecting with said pneumatic, in which the air-pressure is varied in order to cause the pneumatic to actuate the valve, this channel being hereinafter referred to as a 'variable-pressure' channel. For varying the pressure in this channel, the channel is provided with two or more ports, which are governed by separate valves. Suitable connections are provided whereby one of these valves is operated whenever the key corresponding to the sounding-channel is depressed. Each of the other ports is governed by a pneumatic-coupler valve located in a stop-controlled chest and suitably connected to a key corresponding to another sounding-channel, and controlling, through suitable connections, the valve of said channel. Upon the depression of a key connected to a pneumatic-coupler valve, therefore, the valve of the sounding-channel corresponding to that key is actuated, and also the valve of the first-mentioned sounding-channel in case the stop of the stop-controlled chest has been drawn. For reasons which will be obvious to those skilled in the art from the description of the preferred form of my invention the variable-pressure channel is preferably provided with a permanent vent, by means of which the air in the channel is maintained at atmospheric pressure when the valves governing the ports of the channel are in their normal position. Also, preferably, each port which is governed by a pneumatic valve in a stop-controlled chamber and the variable-pressure channel, as such an arrangement, besides possessing the advantages of compactness and simplicity, allows for a simple construction of pneumatic valve.

"In the preferred form of the invention a pneumatic located in a constant-pressure chamber is provided for actuating the valve of each sounding-channel and a variable-pressure channel is provided for each pneumatic. Each of these variable-pressure channels is provided with a port which is governed by a pneumatic valve located in a constant-pressure chamber. These valves are connected to key-controlled channels corresponding to the sounding-channels. The pneumatic-coupler valves are also connected with the key-controlled channels, so that the valve of a sounding-channel is actuated in the same manner whether it is actuated from the corresponding key-controlled channel through a pneumatic valve in a constant-pressure chamber or from a key-controlled channel corresponding to another sounding-channel through a pneumatic-coupler valve."

*United States Letters Patent, No. 760,115, dated May 17, 1904. Application dated Aug. 21, 1903.

The above somewhat involved outline of the coupling appliance under consideration, written after the prevailing fashion of Patent Specifications, will be understood from the following brief description and the adjoining illustration, Fig. CCXLVI., which we have been able to prepare in a carefully detailed manner through the courteous assistance of the Estey Organ Company. The illustration shows a Transverse Section through portion of an Organ adjoining the manual

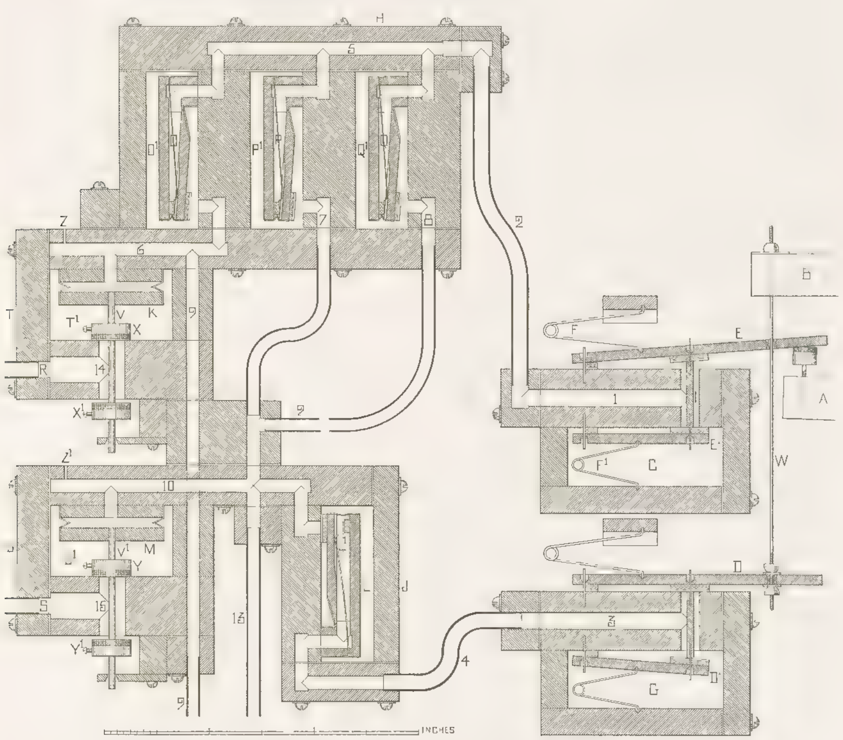


Fig. CCXLVI.

claviers, embracing the key valve-boxes and the Great and Swell coupling devices. A is the tail of the Great Organ key, which operates the linked valves or small pallets of the adjoining key valve-box. This valve-box comprises the continuous or general compressed-air chamber C, the upper board of which is perforated with the vertical valve-throat and the horizontal channel 1 leading therefrom, corresponding to each key of the clavier. The horizontal channel leads into the pneumatic tube 2, in the manner shown. The valve-throat is commanded by the valves attached to the levers E and E^1, which by their position either charge or

exhaust the pneumatic tube 2. In the illustration they are indicated in the exhausting position, the pneumatic tube being in communication, through the valve-throat, with the open air. The valves are linked and held the required distance apart by the small sticker I, which passes vertically through the valve-throat, as shown. By this simple arrangement, one valve is invariably open while the other is closed. The valve-levers are acted upon in contrary directions by the pallet-springs F and F^1. B is the tail of the Swell Organ key, which operates, through the agency of the pull-wire W, the linked valve-levers D and D^1, which command the valve-throat connected with the compressed-air chamber G, and control the supply and exhaust of the horizontal channel 3 leading therefrom to pneumatic tube 4. In all respects the key valve-box of the Swell Organ is the same as that of the Great Organ. The pneumatic tube 2—designated in the Patent Specification the "key-controlled channel"—leads from the Great Organ key valve-box to the coupling-chest H; while, in like manner, the pneumatic tube or "key-controlled channel" 4 leads from the Swell Organ key valve-box to the pneumatic-valve chest J. Returning to the coupling-chest H: O^1, P^1, and Q^1 are "constant-pressure chambers" in which are placed the pneumatic valves O, P, and Q. The chamber O^1, which belongs to the direct unison action of the Great Organ, is constantly charged with compressed air while the Organ is being played: but the chambers P and Q, which belong to the Swell to Great unison and octave coupling actions, are charged with compressed air only when their respective couplers are drawn. The pneumatic valves O, P, and Q have their interiors in communication with the "key-controlled channel" 2 through the horizontal channel 5, in the manner shown. The felt and leather discs attached to the movable boards of the pneumatic valves O, P, and Q command the entrances to the channels 6, 7, and 8—termed in the Specification "variable-pressure channels." The channel 6 leads to the interior of the Great Organ pneumatic K, and also receives the Great to Pedal coupling channel 9. The channel 7 leads, in the unison, to the "variable-pressure channel" 10, and, accordingly, forms part of the Swell to Great coupling action. The channel 8 leads to the "variable-pressure channel" corresponding to, and an octave above, the channel 10, and, accordingly, belongs to the Swell to Great octave coupling action. On this account it is shown broken in the illustration. The "key-controlled channel" 4 leads from the Swell Organ key valve-box, through its channel, to the interior of the pneumatic valve L^1, which is placed in the "constant-pressure chamber" L. This chamber is charged with compressed air while the Organ is being used, as it simply belongs to the direct key action of the Swell Organ. The felt and leather disc attached to the movable board of the pneumatic valve L^1 commands the entrance to the channel 10, which extends from the chamber L to the interior of the Swell Organ pneumatic M, and which, in its passage, receives the Swell to Great unison and octave coupling channels 7 and 12, and the Swell to Pedal coupling channel 13.

We now come to the valve-boxes from which the main pneumatic tubes—designated in the Patent Specification the "sounding-channels"—issue that extend thence to the pneumatic stations or appliances which actuate the pipe-valves or pallets of the Great and Choir wind-chests. The near end of the "sounding-

channel" of the Great Organ is shown leaving the valve-box at R; while that of the Swell Organ is indicated under similar conditions at S. T^1 is the "constant-pressure" air chamber of the Great Organ valve-box T; and U^1 is the corresponding air chamber of the Swell Organ valve-box U. In these "constant-pressure" chambers are fixed the pneumatics K and M, in the form of small oblong bellows, to the moving boards of which are secured the wooden valve-stems V and V^1, carrying respectively the twin disc-valves X and X^1, and Y and Y^1, as clearly shown. These disc-valves are formed of wood faced with felt and leather, and are firmly held in position on the valve-stems by means of the binding screws, as indicated. The disc-valves command the vertical valve-throats 14 and 15, which communicate respectively with the "sounding-channels" R and S. The small "permanent vents" Z and Z^1 connect the two "variable-pressure channels" 6 and 10 with the external atmosphere. Having described the general construction and appointment of the complete appliance, we may now consider what follows the depression of a single Great Organ key.

When the appliance is at rest and no key is touched, the pallets of the key valve-boxes are in the positions indicated at D and D^1 in the Swell Organ valve-box, which close the valve-throats to the open air and open them to the compressed-air chambers. All the pneumatic valves O, P, and Q are expanded by the pressure of their internal springs, and close the orifices of the channels 6, 7, and 8. The expanded condition of the pneumatic valve is indicated at L^1. The "constant-pressure chamber" O^1 is filled with compressed air; and the chambers P^1 and Q^1 are also filled with compressed air, provided their respective couplers are drawn or otherwise brought on. As the "variable-pressure channel" 6 is shut off from the "constant-pressure chamber" O^1, and communicates with the open air through the "permanent duct" Z, there is, accordingly, no compressed air in it or in the attendant pneumatic K. The result is that the latter is collapsed by the upward pressure of the compressed air in the "constant-pressure chamber" T^1; and the attached disc-valves are drawn up, the lower one closing the valve-throat 14 to the open air, and the upper one opening it to the compressed air in the chamber T^1. The compressed air fills the "sounding channel" R, and extending along it to the distant wind-chest appliance renders that inoperative, and the pipe-work remains silent. When all the "constant-pressure chambers" are filled with compressed air, the action which instantly follows the depression of a single Great Organ key is as follows:

When the key is depressed by the finger of the performer, its tail A is raised, placing the valve-levers E and E^1 in the positions shown, cutting off the communication between the compressed-air chamber C and the valve-throat, and uncovering the upper orifice of the valve-throat to the external air. The immediate result of this action is that the interiors of the pneumatic valves O, P, and Q exhaust through their ducts, the horizontal channel 5, and the "key-controlled channels" 2 and 1, into the open air. The pneumatic valves O, P, and Q collapse, in the manner shown, under the pressure of the compressed air which surrounds them, uncovering the orifices of the channels 6, 7, and 8, and allowing the compressed air to enter them. The compressed air from the channel 6 enters the interior of the

pneumatic K, placing it in equilibrium, and allowing its movable board and its attached disc-valves to fall into the positions indicated. This movement opens the valve-throat 14 to the open air and allows the "sounding channel R" to exhaust, and, in exhausting, actuate the pneumatic mechanism at the Great Organ wind-chest and sound its pipe-work. In precisely the same manner the compressed air flowing through the unison and octave coupling channels 7 and 8, places the pneumatics and disc-valves of the Swell Organ valve-box U in the exhausting positions, causing the pipes of the Swell Organ to sound in unison and in the octave simultaneously with the unison pipes of the Great Organ. To render these couplers inoperative it is only necessary to shut off the compressed air from the coupling chambers P^1 and Q^1. The Great and Swell to Pedal couplers act in the same manner as the manual couplers, exhausting the "variable-pressure channels" 6 and 10 through the pneumatic tubes 9 and 13, which extend upward from the Pedal Organ coupling-chest.

The pneumatic valves used in this coupling action, and which are represented in longitudinal section at L^1, O, P, and Q, form the subject of a separate part of Mr. Haskell's patent. Alluding to this form of pneumatic valve the inventor makes the following claim:

"A pneumatic valve for Organs having, in combination, a channeled supporting-base having a shouldered seat, a stationary board secured to said base, a movable board having a reduced end adapted to said shouldered seat and having a groove on its inner face, a flexible hinge connecting said reduced end to said base, a flexible sheet constituting one end and two sides of the chamber formed between said base and movable and stationary boards, said sheet overlapping said flexible hinge at opposite sides, a valve on the outer face of said movable board, a pad between said movable and stationary boards, and a spring secured to said base with its free end entering said groove in said movable board, said spring bearing upon said movable board to move it away from said stationary board."

All the parts of the pneumatic valve above mentioned are accurately delineated to scale in Fig. CCXLVI., and, accordingly, no further description is necessary. We may, however, close this part of our present subject with the following words of the inventor: "The object of the present invention is to provide a pneumatic valve for Pipe Organs of improved and simplified construction which is quick and certain in its action, and which can be used in various places in an Organ to govern the ports of air-channels, and by the use of which the general construction, arrangement, and mode of operation of the various parts of an Organ may be simplified and improved."

It is only necessary for the purposes of the present Chapter to illustrate and describe one other tubular pneumatic coupling action, constructed on entirely different lines from those previously described. This coupling action is the invention of Mr. Philipp Wirsching, Organ Builder, of Salem, Ohio, and is extremely ingenious and complete. Here all the key- and draw-stop valves or pallets are in the open air, and in operation simply uncover the orifices of the ducts in, or communicating with, the different coupler-boards. To enable the reader to readily understand the operation of the entire action, as shown in the general Transverse

Section, we shall first illustrate and describe a single coupler-board, selecting that directly connected with the Swell Organ clavier. Diagram 1, Fig. CCXLVII., is a Transverse Section of the coupler-board just alluded to. This extends throughout the length of the clavier, receiving as many pallets or valves as there are keys in its compass. One of these pallets is shown at B, arranged so as to be raised from its seat on the coupler-board A when the key is depressed by the performer. The tail of the key is indicated at C. One end of the pallet-spring which holds the pallet against its seat, and imparts the necessary weight to the key-touch, is shown at D. The coupler-board A is formed of three distinct sections or divisions: one belonging to the direct unison action of the Swell Organ; one to the

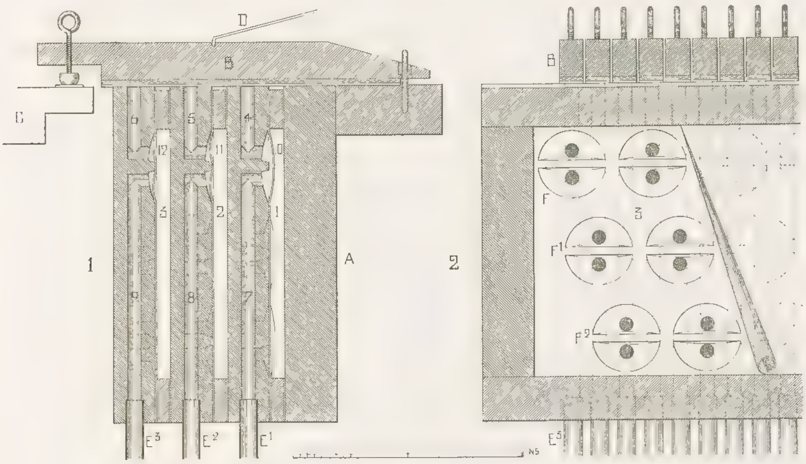


Fig. CCXLVII.

octave coupler on the same clavier; and one to the sub coupler on the same clavier. 1, 2, and 3 are chambers which extend the length of the clavier. Chamber 1, which belongs to the direct unison action, is normally filled with air at the ordinary pressure of the atmosphere; while the chambers 2 and 3 are constantly charged with high-pressure wind while the couplers are not drawn, and which are placed in communication with the open air when the couplers are brought into operation. Adjacent to the chambers are the several borings 4, 5, 6, 7, 8, and 9. The upper orifices of the borings 4, 5, and 6 are opened and closed by the pallet B, and the lower openings of the borings 7, 8, and 9 receive the tubes E^1, E^2, and E^3, which are connected, through a so-called "mixer-bar," with the pneumatic station of the Swell Organ wind-chest. The inner orifices of each pair of borings open into semicircular, shallow sinkings, as shown at F, F^1, and F^2, in Diagram 2, which is a Longitudinal Section through one end of the chamber 3. It will be observed that each

pair of these shallow sinkings are separated by a narrow partition, shown in section in Diagram 1, and in face in Diagram 2. Over the surface of each board, with the exception of the sinkings and their partitions, is glued a fine skiver of sumac-tanned leather, forming circular diaphragms over all the associated sinkings. These diaphragms are indicated, in the open condition, at 10, and, in the closed position, at 11 and 12, in Diagram 1. In Diagram 2 the leather covering which forms the diaphragms is shown partly removed, so that the semi-circular sinkings and the orifices of the upper and lower borings can be clearly indicated in their correct relative positions. Transverse Sections of the key-pallets are shown at B in Diagram 2.

The operation of this coupling appliance is extremely simple. So long as the chambers 2 and 3 are charged with high-pressure wind from the draw-stop action, the diaphragms are pressed tightly against the partitions of the sinkings, and all communication is cut off between the lower and upper borings. Under these conditions, the lifting of the key-pallets has no effect, and the couplers remain inactive. Now, when a coupler is drawn, the high-pressure wind is allowed to exhaust from the corresponding chamber, and all pressure is removed from the surface of the diaphragms. A clear communication is immediately instituted—over the partitions and under the diaphragms—between the lower and upper borings, the diaphragms assuming the inflated condition indicated at 10. Accordingly, when a key-pallet is raised by the tail of a depressed key, the compressed air in the pneumatic tubes exhausts through the lower and upper borings into the open air, and speech is given to the pipe-work on which the coupler acts.

As we have already said, the chamber 1, belonging to the direct unison action of the clavier, is normally in an exhausted condition, that is, it is in communication with the open air. So long as this condition obtains, a free communication exists between the lower and upper borings. But if at any time it is desired to silence the unison, and allow the octave voices to speak alone, it is only necessary to charge the chamber 1 with the high-pressure wind through the appliance provided for that purpose, commanded by a draw-knob or a thumb-piston. The above description will enable the reader to readily understand the complete pneumatic coupling action shown in the general Transverse Section given in Fig. CCXLVIII. Here the coupler-board just described is indicated at A in its proper position with respect to the other portions of the coupling action. One of the Swell Organ keys is shown complete at C, and its corresponding pallet at B. The pallet is held firmly against its seat, and the key receives its proper weight of touch, by the pressure of the spring B^1. D is a complete Great Organ key, connected with its corresponding pallet F by the tapped-wire D^1, both being under the influence of the spring F^1. E is a tube-board so formed as to serve as a compact valve-seat to the pallet F, and to properly receive the ends of the numerous tubes which lead thence to the Great Organ coupler-board G. This coupler-board is constructed internally in precisely the same manner as the Swell Organ one, previously described, and fully detailed in Fig. CCXLVII., and, accordingly, need not be specially described here. The same remark applies to the Pedal Organ coupler-board, the Transverse Section of which is given at H in the lower part of the Fig. CCXLVIII. The pallet

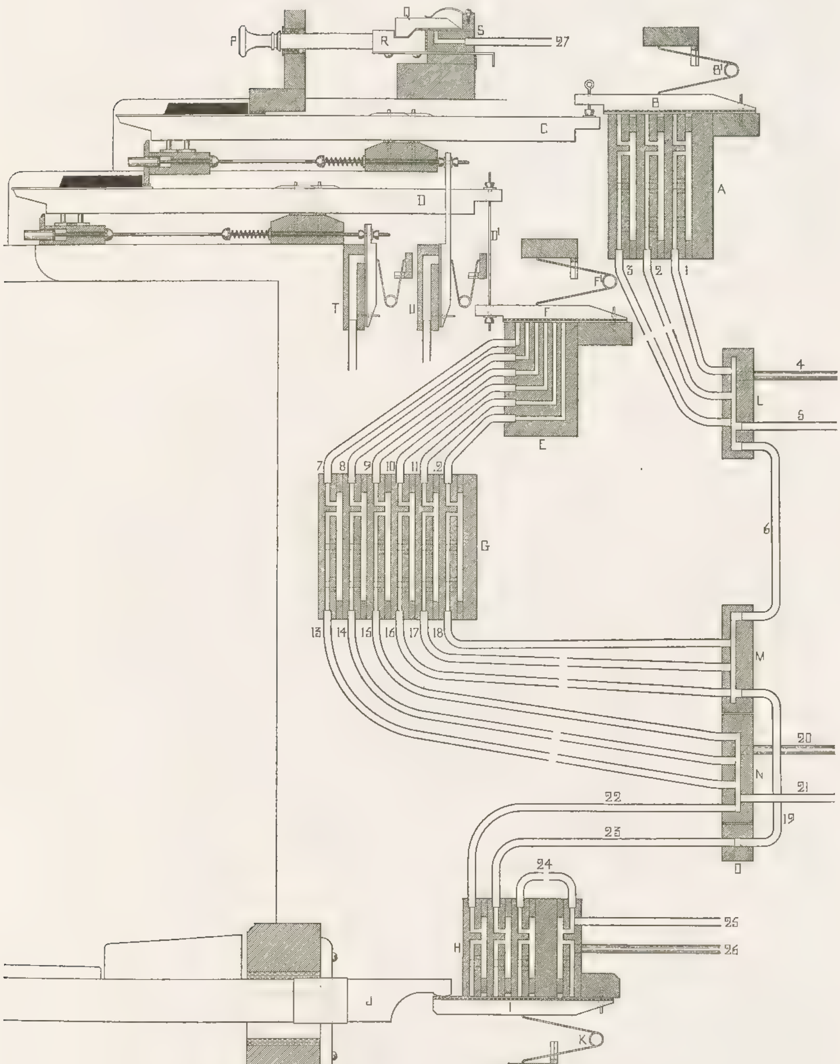


Fig. CCXLVIII.

which commands the four borings belonging to a single note in this bar is indicated at I, in touch with its corresponding pedal key J, and held against its seat by the spring K. We now come to the "mixer-bars," transverse sections of which are shown at L, M, and N. In speaking of these bars and the several tubes connected with them, it must be understood that we substantially confine our remarks to what belongs to a single key.

Into the bar L the three tubes from the Swell Organ coupler-board enter at one side, and communicate with a vertical boring or duct. Tube 1 belongs to the direct unison action; tube 2 belongs to the sub coupler acting on the Swell Organ itself; and tube 3 belongs to the octave coupler also acting on the Swell Organ. The tube 6 which enters at the other side of the board, and communicates with the vertical duct, belongs to the Swell to Great coupling action. The tubes 4 and 5 extend from the board to the C and C♯ sections of the Swell Organ wind-chest. The six tubes which connect the Great Organ tube-board E with the coupler-board G, and the corresponding six tubes which extend thence to the "mixer-bars" M and N, form part of the direct unison action and the couplers of the Great Organ. Tubes 7 and 13 belong to the octave coupler acting on the Great Organ itself; tubes 8 and 14 belong to the sub coupler acting on the Great Organ itself; tubes 9 and 15 belong to the Great Organ direct unison action; tubes 10 and 16 belong to the Swell to Great octave coupler; tubes 11 and 17 belong to the Swell to Great sub coupler; and tubes 12 and 18 belong to the Swell to Great unison coupler. Into the bar M the three tubes of the Swell to Great couplers enter at one side, and communicate with a vertical duct. From the upper end of this duct rises the tube 6, before mentioned, connecting the Swell with the Great Organ; while the tube 19, connecting the Swell with the Pedal Organ, communicates with the lower end of the duct, as indicated. In like manner, the tubes belonging to the Great Organ direct unison and its sub and octave coupling actions enter at one side of the "mixer-bar" N, and communicate with the vertical duct therein. The tube 22, belonging to the Great to Pedal coupler, also enters this vertical duct. The two tubes 20 and 21 extend from this board to the C and C♯ sections of the Great Organ wind-chest. It will be understood that when the Great and Swell wind-chests are undivided, the tubes will extend to the single chests from the "mixer-bars" L and M. The tube 23, belonging to the Swell to Pedal coupler, enters the bearing-bar O, and is continued by the tube 19, the vertical duct in the "mixer-bar" M, and the tube 6, to the vertical duct in the upper bar L, completing the connection between the Swell and Pedal Organs. The broken tubes 24 belong to the Pedal Organ octave coupler on itself. Finally, the tubes 25 and 26 extend to the C and C♯ sections of the Pedal Organ. It will be observed that in none of the coupler-boards are the diaphragms indicated. These have been omitted to prevent confusion in an illustration drawn to so small a scale. The student of organ-building will experience no difficulty in filling in the want in imagination, assisted by the key to the entire system furnished by Diagrams 1 and 2, Fig. CCXLVII.

At P, in the upper part of Fig. CCXLVIII., is shown a coupler draw-knob. On this knob being drawn the pallet Q is raised from its seat S by the action of

the inclined plane in the block R. The tube 27 extends from the escape-duct or boring in the pallet-seat S to the simple appliance which charges the chambers in a coupler-board with high-pressure wind when the coupler is not drawn, and places them in communication with the open air when the coupler is drawn. The pneumatic actions indicated at T and U, operated by the thumb-pistons located under the Great and Swell claviers, as shown, belong to a pneumatic adjustable combination action, which is described and illustrated in the following Chapter.

Other forms of pneumatic coupling actions have been contrived by certain ingenious organ builders; but as all those of any great practical value are constructed after one or other of the principles presented in this Chapter, we do not consider it necessary to describe or illustrate them.

CHAPTER XXXII.

THE COMBINATION ACTION.

THE Combination Action of the Organ is that portion of its mechanism by means of which certain fixed or adjustable combinations of speaking stops and couplers are brought into use by single operations of the performer's hands or feet. The term "composition action" has been very commonly used by writers on the Organ for this important part of its mechanical structure; but we question the propriety of employing such a term, for in drawing a number of stops for the purpose of producing a compound tone, we do not *compose* the stops or their voices, we *combine* them.*

* It seems to us strange that the inconsistency in this direction should not have been evident to the English writers on organ-building, for they have been compelled to use the words "combinations," "combining," and "combined," in speaking of groups of speaking stops. For instance, in "The Organ," by Hopkins and Rimbault, the following passages occur (the italics are our own):

"Besides keeping them separate, the Stops of each department should further be placed where they can be *combined* or changed with the least difficulty to the performer." Then further on in the same paragraph: "The Great Organ Stops are more frequently brought under the control of the feet of the performer by means of *Composition Pedals* than those of any other department."

"The Swell and Choir Organ Stops are not nearly so often acted upon by *Composition Pedals*. . . . . As the bass part of the music can be continued by the Pedals, the left hand can, with a little contriving, be for a moment spared for effecting the necessary changes in the *combinations*."

Another important writer on the Organ—Mr. F. E. Robertson—is equally illogical in the use of the term we object to. In his "Practical Treatise on Organ-Building" we find the following: "The *composition pedals*, by one movement of the foot, set the *combinations* they are built for, and for a large manual there should be three—*p. mf. f.* There are single- and double-acting *compositions*."

The same writer remarks: "Roosevelt has introduced a very ingenious *composition action*, the merit of which is that the player can build up his *compositions* at the moment." This latter remark would be quite appropriate applied to improvisation or extempore playing. Roosevelt never used the term "*composition action*" so far as we can learn. This writer uses the correct term once where he says: "Another form of adjustable *combination action* is shown," etc.

Later writers thoughtlessly follow, as might be expected, the illogical terminology which custom has so far established. In his "Organ Construction," Dr. J. W. Hinton uses the term "*composition pedals*." Mr. J. Matthews, in his "Handbook of the Organ," page 42, says, under the heading "*Composition Pedals*": "The *combinations* from *p* to *ff* should always be arranged from left to right." Then, on the same page, under the

When and where a combination action was first devised and applied to the Organ we have been unable to discover: but we may reasonably suppose that so soon as the Organ assumed proportions that rendered it difficult, if not impossible, to quickly change a large number of stops at one time by hand; or to suddenly change from a *piano* combination to a *forte* one, or vice versa, some mechanical expedient was resorted to whereby such important changes could be instantly made without requiring the hands to leave the claviers. The early essays in this direction were doubtless of the most tentative character, and very circumscribed in their operations. The heavy draw-stop actions and the long movement of the draw-stop rods in the old Organs were most unfavorable to the development of the combination action; and we can safely assume that it was only when the construction of the slider and pallet wind-chest was brought to perfection, and a comparatively short travel was given to the draw-stop mechanism, that an easy and satisfactory combination action became practicable, and was introduced in the form we have found in the ordinary mechanism of the Organs of the early part of the last century.

The early combination actions were frequently single-acting, that is, they operated at one time in only one direction. They were actuated by foot-levers; and the depression of one lever would draw a certain combination of stops, while another lever would reduce that combination by pushing in certain of its stops. The former would draw a *forte* combination, while the latter would leave it a *piano* combination. The inconvenience of these single-acting levers was quickly realized by progressive organ builders, and double-acting combination levers became the order of the day. These double-acting levers actuated a mechanism which simultaneously drew a certain fixed combination, and pushed in any stops, already drawn, which did not belong to that fixed combination. All subsequent combination actions have invariably been double-acting.

The combination actions which were commonly used prior to the introduction of pneumatic appliances are those known as fan actions, constructed, in a very simple manner, with pivoted fans or blades of hardwood, or of metal and wood, which operate on studs projecting from the draw-stop rods or traces, adjoining the stop-jambs, or in some other locality where the traces can be conveniently brought close together, parallel to each other, and on one plane. The fans are moved by foot-levers, each of which actuates two fans, which simultaneously operate in opposite directions, one fan drawing certain stops, while the other pushes any in that may be already drawn and which do not belong to the set combination. When the foot-lever is released, it is recovered by a coiled spring, and the fans return to their inoperative positions, leaving all the stop-rods free to be moved by hand, or by the

heading *Combination Pistons*, he says: "If the Organ contains Pistons in addition to *composition pedals*, they may be made to give *special combinations*."

Mr. Thomas Elliston, in the Vocabulary appended to his work entitled "Organs and Tuning" says: "Composition pedal. Forms a set *combination* of stops when used." In the body of the work he says: "*Composition pedals*. . . . push in and draw out at the same time such stops as are required to form the *combinations* set upon the pedals by the builder."

It is surely absurd to speak, in one breath, of a *composition pedal* producing a *combination;* while it would be equally absurd to speak of a *composition pedal* producing a *composition* of stops and couplers. The terms *composition action* and *composition pedal* should drop out of Organ terminology altogether.

fans connected with other foot-levers. A single fan only is required in connection with the foot-lever which draws all the stops of any division of the Organ. In this case there are no stops to push in. The full combination is reduced to any other set combination by the operation of the negative fan belonging to that combination. It is convenient to speak of the associated fans as positive and negative, it being understood that the former in all cases produces the combination, while the negative fan removes all the stops which may have been previously drawn and do not form any part of the set combination. The positive and negative fan movement has been, and is still, used in the most reliable adjustable combination actions, as is shown further on in the present Chapter.

Mechanical combination actions have been made which act directly on the ends of the wind-chest sliders, but such actions are necessarily circumscribed and insufficient. It is rare that an action of this description extends beyond two single operations—one of which draws certain sliders, while the other pushes in certain sliders which may have been drawn. This form of action usually consists of two parallel rollers furnished with arms which act on blocks attached to the projecting ends of the sliders not connected with the ordinary draw-stop action. As this latter action must always remain free, it is necessary that the roller-arms of the combination action be in no way attached to the sliders, and that they retire from contact with the blocks on the sliders, after they have moved them. Each roller has to be actuated by a special foot-lever which is returned by a spiral spring.*

In Organs in which the pneumatic lever was introduced in connection with the key action, it was not unusual to find the combination action constructed with pneumatic motors. This arrangement was effectively carried out, in connection with thumb-pistons, by the late Mr. Henry Willis in the Organ in St. George's Hall, at Liverpool, erected in the year 1855. The combinations drawn by the pistons were not temporarily adjustable; that is, unless the organ builder altered the combinations by re-adjustment of the actuating mechanism, all the combinations were permanently set on the several pistons. It is only in very recent years that English organ builders have realized the importance of an adjustable combination action. It was some years after Mr. Hilborne L. Roosevelt applied his "Patent Adjustable Combination Action" to his fine Organs, that any attempt was made in a similar direction by a European builder. To Americans belongs the credit of having invented and successfully applied the adjustable combination action to the Organ. Let the mechanical action or the pneumatic combination mechanism be ever so complete, and the means of controlling it be of the most convenient character: unless it is immediately adjustable by the hands of the performer, it is hopelessly imperfect from a tonal point of view. A fixed combination is only useful up to a certain

* We added a combination action of this description to one of the wind-chests of our own Chamber Organ, one roller of which drew all the sliders of the chest, while the other reduced the full combination to a *piano* one, by pushing all the sliders in save those belonging to two soft stops.

Mr. F. E. Robertson, in "A Practical Treatise on Organ-Building," gives an illustration on Plate XIV. of an action of a similar nature, but it is double-acting and capable of producing a single combination only. The rollers are so connected by small arms as to move together; one roller is shown drawing a slider, while the other is pushing in the adjoining three sliders. The author very properly designates this an "old-fashioned arrangement." It certainly is a very undesirable one.

point, while it is always disappointing, if not embarrassing, to the virtuoso, who naturally desires his own system of registration, and who requires special combinations of stops for every composition he performs. It is not necessary to dwell further on the old-fashioned fixed combination actions; so we may now direct the reader's attention to certain representative adjustable actions.

The earliest essay in the form of a complete and practical adjustable combination action is that carried to comparative perfection by the late Mr. Hilborne L. Roosevelt, of New York, about the year 1882, and introduced, among other instruments, in the Organ he built for the First Congregational Church, of Great Barrington, Mass. We had a favorable opportunity of inspecting this important Organ, while in course of construction, during our first visit to New York in the year 1883. As we have given, at length, Mr. Roosevelt's published description of the adjustable combination action introduced in this Organ in our Chapter on the Church Organ, it is only necessary here to describe the action in a somewhat more detailed manner. A Vertical Section showing all the essential parts of this action is given in Fig. CCXLIX. The exterior portions, or those seen in the front of the Organ, and directly over the several ranges of the draw-stop knobs at each end of the manual claviers, consist of horizontal rows of small, rocking tablets, each row comprising as many tablets as there are speaking stops and couplers belonging to the division of the Organ they affect. There are as many rows, exactly alike, as there are combination foot-levers or thumb-pistons connected with the special division. The rocking tablets have the names of the speaking stops and couplers inscribed on them in a uniform and approved order, or that in which the inscribed draw-stop knobs are arranged in the stop-jambs below. Side Views of three of the rocking tablets are shown at A, B, and C in Fig. CCXLIX. They are pivoted on studs fixed in the panel D. The tablets A and B are in the "off" position, while the tablet C is shown in the "on" position. They are temporarily held in these positions by the small catch-springs I, which do not interfere with the manipulation of the tablets. Pivoted in slots in the ends of the tablets are the steel wires 1, 2, 3, 4, 5, and 6, which pass through borings in the front panel D and then through tapered holes in the vertical draw-stop trace E, as indicated by dotted lines. It will be observed that, according to the position of the rocking tablet, the end of one or other of the associated wires projects from the draw-stop trace. To place the wires in the positions indicated at 1 and 2 and at 5 and 6 is all that the tablets are called upon to do under the manipulation of the performer. The trace E is connected by means of a metal square with the draw-stop knob F in the manner shown. The advantage of this arrangement lies not only in the fact that the trace can be moved by the draw-stop knob, but that, when the trace is moved by the combination mechanism, the same is visibly recorded by the draw-stop knob moving in a corresponding manner. The trace is connected at its lower end with a slide-valve action, whereby the pneumatic tube of the draw-stop pneumatic is charged with compressed air or allowed to exhaust into the open air. This action is shown at G within the compressed-air chamber K; and the end of the pneumatic tube is shown at H, and the exhaust-port at J. We now come to the combination mechanism, which is clearly depicted, at rest, in the left of the illustration. N O,

P Q, and R S, are pivoted iron rollers, which extend across the series of draw-stop traces, and have triple lever-arms. Two arms of each roller carry a fan or bar of wood, which operates on the projecting ends of the steel wires, while the other arm is pivoted to, and moved by, a vertical rod. The rods which move each pair of

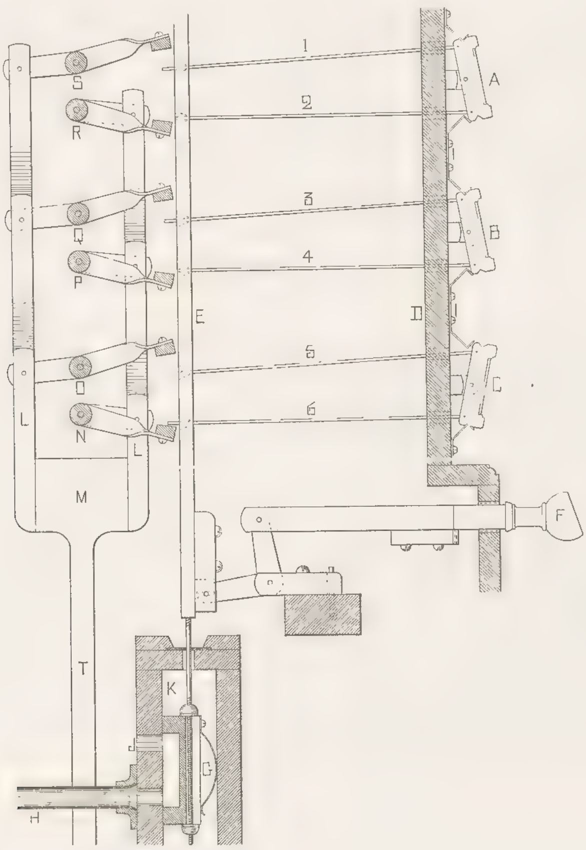


FIG. CCXLIX.

rollers and fans are attached to the spread head of a motor-rod, in the manner indicated at M. Accordingly, when the motor-rod T, carrying its vertical arms L L, is pushed upward, either by a foot-lever, or by a power-bellows commanded by a thumb-piston, the rollers N and O partly revolve and move their fans toward each other. In doing so the lower fan comes in contact with the projecting end of

the wire 6, and moves up the draw-stop trace E, and, through the agency of its slide-valve, brings the corresponding speaking stop on the clavier. So long as the wires 1 and 3 are in the positions indicated, the contiguous upper fans will, in their movement, invariably depress the draw-stop trace and silence the corresponding stop. It is obvious, therefore, that, whichever rocking tablets, in a horizontal series, are set as shown at C, the stops they represent will be drawn; while all the stops represented by the tablets which remain in the position indicated at B will be left undrawn, or silenced if they have been previously drawn. By whatever means the motor-rods are moved, provision has to be made for the rods to return to their inoperative position, so as to open their fans, and leave the draw-stop traces perfect freedom of action. All the fans are shown in their inoperative position in Fig. CCXLIX. The rocking tablets were usually made by Mr. Roosevelt of different hardwoods, with the view of readily indicating the divisions of the Organ which they affected; and the draw-stop knobs were made of the same woods to accord.

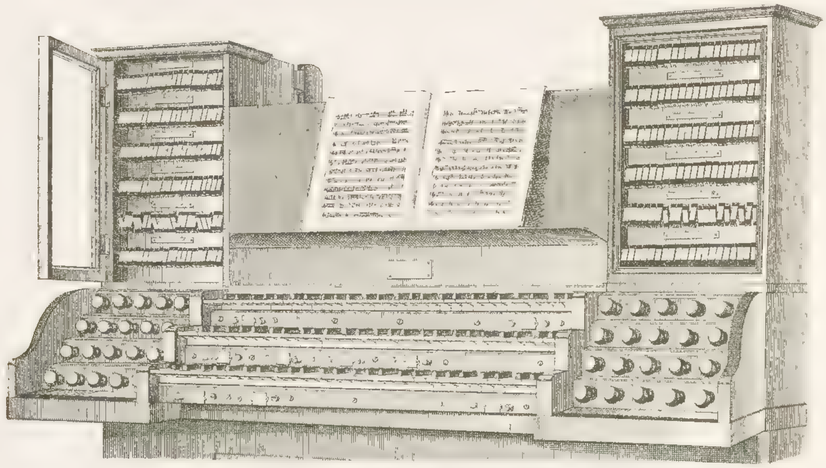


Fig. CCL.

The manner in which the several series of rocking tablets were usually arranged, and placed with respect to the corresponding draw-stop knobs, is shown in the Perspective View of a Roosevelt key-case given in Fig. CCL. The tablets were protected from dust and interfering fingers by being covered with glazed doors, as indicated in the illustration. As all the series of tablets are in full view, the performer can at all times see the stops that are commanded by the several foot-levers or thumb-pistons, and, accordingly, his memory is not unduly taxed. The chief, and perhaps the only, serious disadvantage which attends this combination action lies in the fact that it cannot be used in a detached console. This

consideration doubtless induced the late Mr. Frank Roosevelt to abandon its use in favor of the more compact adjustable combination we shall now describe.

In the year 1889, Mr. Salluste Duval, of Montreal, Canada, patented an adjustable combination action,* which he speaks of in the preamble of his Specification, thus:

"The object of my invention is to produce a mechanism by which the organist can immediately and simultaneously bring into effect any stop or stops previously selected, while at the same time all other stops are drawn in or left untouched, all depending upon the previous setting of the mechanism, the entire operation being accomplished by a single movement, while all stops are free to be operated in the usual way, excepting only at such time as the mechanism in question is in operation. I accomplish this result preferably by mechanism having for each combination pedal, piston, or movement a separate pedal, piston, or movement to do the setting of the stops to be drawn on, off, or left untouched, after the desired selection has been arranged or selected, by moving the stop-knobs themselves in the usual way, all operating in connection with the mechanism of the stop prepared."

A Diagram of this action is given in Fig. CCLI., in which only a single set of

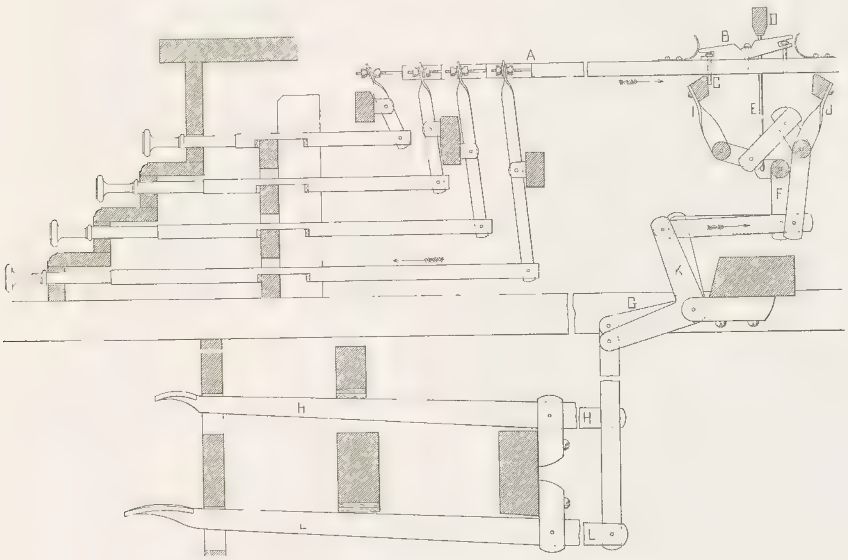


FIG. CCLI.

fans is shown. In actual work, of course, there is a similar set of fans with all its mechanical accessories provided for each combination foot-lever or thumb-

* United States Letters Patent, No. 416,158, dated December 3, 1889. Application filed August 17, 1888.

piston in the Organ. All the stop-traces which are moved by the series of fans are connected with the several draw-stop rods by rocking levers in the manner represented. The traces, which are indicated at A, are run parallel and in the same horizontal plane, the rocking levers being inclined sidewise for that purpose. Each trace has, over each pair of fans, a "rocker," B, pivoted on a center-pin, and carrying, in slots at its ends, controlling-pins, which pass through holes in the trace so as to be engaged by the fans. One of these controlling-pins, in the operative position, is shown at C. The closing of the fans, while the pin is in this position, will draw the stop by moving the trace in the direction indicated by the arrow.

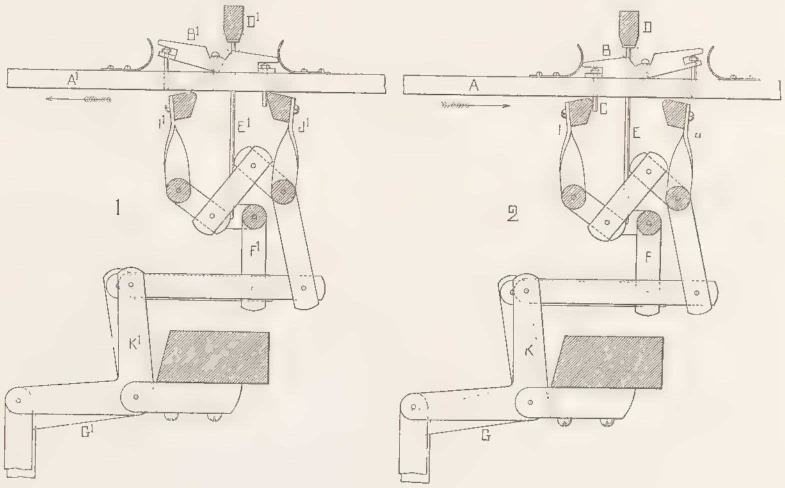


Fig. CCLII.

The rocker B is set so as to draw or put in the stop by means of the setting-bar or "pusher" D. This is pulled down by the rod E, the squares F and G, and the setting foot-lever H. If this mechanism is moved, in its present relation to the other portions of the action, it will reverse the position of the rocker B and its controlling-pins. The fans will no longer draw the stop, but, on the contrary, will put it in, should it have been previously drawn by hand or any other set of fans. The fans I and J are operated simultaneously by the several lever-arms disposed in the directions shown, the square K, and the combination foot-lever L. The different motions of all the parts can be readily traced without a detailed description of the same. But to enable the reader to thoroughly understand the action of the fans we may direct his attention to the two Diagrams given in Fig. CCLII. To prevent any possibility of confusion, the same indicating letters are used in them as in the corresponding portions shown in the preceding illustration. In Diagram 1 the rocker B^1 has been set in the position indicated, by

the setting-bar D[1], while the stop remained undrawn, and, accordingly, when the stop has been subsequently drawn, the operation of the fan J[1] is to push the stop-trace A[1] in the direction of the arrow, and to silence the corresponding stop. The fans I[1] and J[1] are here shown in their closed position, the latter having completely moved the stop-trace. In Diagram 2 the rocker B has been set in the position indicated, by the setting-bar D, while the stop was drawn; and, accordingly, when the stop has subsequently been put in, either by the hand of the performer or by another fan action, the operation of the fan I is to push the stop-trace A in the direction of the arrow, and to draw the stop. As in the preceding case, the fans I and J are here shown in their closed position. The open position of these fans, ready for action, is shown in Fig. CCLI.

Certain American organ builders have obtained Letters Patent for mechanical adjustable combination actions, the chief aims of which appear to be the retention of the general principle of operation presented in the Duval action, and the introduction of sufficient variation in the mechanical adjustments to secure special protection. On examination, however, the patented appliances show no decided improvements on the early Duval action, while more complicated mechanical systems render the appliances in some respects markedly inferior to it.

In the year 1891, Mr. George S. Hutchings, Organ Builder, of Cambridge, Mass., took out Letters Patent for an adjustable combination action in which the following claims appear:*

"A combination action for pipe-organs, consisting of adjustable register-rods, each having an oscillatory cam provided with a duplex cam-surface, vertically-adjustable tripper-bars acted directly upon by the cam-surfaces of the cam, rocker-bars directly acting upon the opposite ends of the cam, a pedal, connecting mechanism for imparting the requisite movements to the register-rods, and locking and releasing devices movable with the register-rods for locking and releasing the tripper-bars.

"The combination, in a pipe-organ action, of a push-button, a register, a register-rod, a tripper-bar rod, pivoted bell-crank levers and links, respectively connecting the push-buttons and the register with the register-rod and the tripper-bar rod, an oscillatory cam pivoted to the register-rod and provided with a duplex cam-surface, a vertically-movable tripper-bar arranged beneath and acting directly upon the duplex cam-surface of the oscillatory cam, a combination-rod connected with a treadle, rocking-bars located above the oscillatory cam, and a connection between one of the rocker-bars and the combination-rod."

From the above claims some idea of the appliance can be obtained, or, at least, a conception of the number of mechanical parts which enter into its construction can be formed by any one versed in organ mechanism; but to throw some more light on the subject we add the following extract from the Specification:

"In my invention I avoid a multiplicity of combination-pedals, and provide a single pedal which fulfils all the conditions required for an indefinite number of combinations, since the combinations can be quickly and correctly made, even while the organist is performing. Again, while playing upon one manual the performer can press in the push-button, and then as opportunity presents itself, as when either hand can be spared for an instant, he can draw

* "Combination Organ Stop-Action." United States Letters Patent, No. 451,380, dated April 28, 1891.

such stop or stops as he may desire for his next movement; and, therefore, need give no further attention to the push-button or pedal, as the first movement of the latter releases the push-button, which immediately resumes its normal position, and the tripper-bar falls out of the way of the cams before the rocker-bar can come in contact with either wing of the cams."

From the above description it will be gathered that there is only a single combination foot-lever; that only one combination can be set on the entire Organ at one time; that the performer, while he is using one combination, has to find time and a hand at liberty to first press in a "push-button," and then draw all the stops he may require for a subsequent combination. The disadvantages attending such a method of procedure are too obvious to require comment.

In the year 1892, Mr. Jesse Woodberry, Organ Builder, of Boston, Mass., took out Letters Patent for an adjustable combination action,* which presents the common features of rocking catches, and double-acting fans operating on the same. The following outline of the appliance is extracted from the Patent Specification:

"My invention relates to adjustable combination stop-actions for pipe-organs, whereby any previously-selected combination of stops upon any combination-pedal may be simultaneously brought into effect by the organist at any desired time and as often as may be required; and my invention has for its object to simplify the construction of the mechanism by which this result is accomplished and reduce the friction of the working parts to a minimum.

"To this end my invention consists in a novel mechanism for setting any required combination of stops so that they may be 'drawn on' simultaneously by the proper pedal, and also in a mechanism of peculiar construction connected with the combination-pedals for moving the register-rods or stop-bars in or out in order to bring into action such combinations of stops as may have been previously determined upon and set by means of the setting mechanism.

"My invention also consists in providing the register-rods or stop-bars at their front ends with bent or inclined portions arranged in groups or series and extending from the common level of the said register-rods to their knobs or handles arranged in a vertical plane, thus economizing space and enabling me to dispense with the lever mechanism hitherto employed for connecting the register-rods with their knobs or handles."

The adjustable combination action above outlined is in several particulars superior to that patented by Mr. Hutchings. It has separate foot-levers to command the several combination movements; and, accordingly, all the required combinations can be set by the organist before commencing to play. This is essential in all properly-constructed adjustable combination actions.

The latest and the simplest thoroughly efficient pneumatic adjustable combination action known to us is that recently invented by Mr. Philipp Wirsching, Organ Builder, of Salem, Ohio, and of which we give a Longitudinal Section in Fig. CCLIII. It is based, as can be readily seen, on the fan-motion which obtains in Duval's combination action just illustrated and described: but beyond this all likeness ceases. Instead of the fans being operated by a system of levers, forming a somewhat complicated and cumbersome chain of mechanism, in the Wirsching

* "Combination Organ Stop-Action." United States Letters Patent, No. 481,089, dated Aug. 16, 1892.

appliance the fans are actuated by small power-bellows to which they are directly connected, and which, on being inflated by the admission of compressed air, move the fans in the directions required, and, through them, the several parallel draw-stop traces. The action is commanded by thumb-pistons, which, on being pushed in, simply uncover to the open air the orifices of small pneumatic tubes and allow them to exhaust. The instant this takes place, the associated fans act and move the several draw-stop traces out and in, in accordance with the combination previously set on the piston. On releasing the piston, it returns under the action of a spring, and the fans immediately resume the open and inoperative position, leaving the manual draw-stop action perfectly free to be operated directly by the performer, or the combination to be altered by the fan action belonging to another thumb-piston, as circumstances may dictate.

At A, A^1, and A^2, in Fig. CCLIII., are shown the manual draw-stop knobs and rods, pivoted to the rocking levers B, B^1, and B^2, which, in turn, are pivoted to the horizontal and parallel traces C, C^1, and C^2. In each of the traces are pivoted, in slots, as many small adjustable catches as there are thumb-pistons provided in the division of the Organ to which the draw-stop traces belong. Two of these adjustable catches are indicated, in different positions, at D and D^1. The traces are carried past all the appliances belonging to the several thumb-pistons, until they pass through a supporting register, and terminate in thin, projecting inclined pieces, as indicated at E. The office of these will be explained further on. Leaving the draw-stop traces for the present, we may now direct attention to the adjusting or setting action. G is the setting-rod and knob belonging to one of the thumb-pistons, pivoted to the rocking lever G^1, which, in turn, is pivoted to the horizontal rod G^2. It will be understood that there are a draw-knob, rocking lever, and horizontal rod, as above mentioned, for each thumb-piston introduced in the Organ. Pivoted to the rod G^2 is the metal arm H, which actuates the transverse roller H^1. This roller has two other arms (one shown at H^2), which carry the transverse setting-bar H^3. This bar is formed of light wood faced with felt in the manner indicated. The horizontal rod G^4 and its setting attachment I, I^1, I^2, and I^3,—similar in all respects to that just described—belong to another piston action. Between the two setting attachments shown there may be as many others as the number of thumb-pistons call for. Accordingly, the action is shown broken, between the setting attachments, in Fig. CCLIII. Below the horizontal and parallel draw-stop traces is located the entire pneumatic fan action belonging to them. As each thumb-piston has a special fan movement, and as they are all precisely alike, it is only necessary for one to be fully described. J and J^1 are two power-bellows, hinged at J^2 and J^3, and to the outer or movable boards of which are screwed the iron arms K and K^1, carrying at their free ends the wooden fans K^2 and K^3. These fans are pressed apart and the power-bellows collapsed by means of the spring L. A similar motion is given to the fans, to and from each other by the links attached to the movable boards of the bellows, one set of which is indicated (chiefly by dotted lines) at L^1. It is obvious that when the power-bellows J and J^1 are simultaneously expanded by compressed air, the fans K^2 and K^3 will be moved toward each other, and will act on any object in their path.

When, on the other hand, the compressed air is allowed to exhaust into the atmosphere, the bellows will immediately collapse, and the fans move apart and resume their inoperative position, under the pressure of the spring L. Between, and opening into, the power-bellows J and J^2 is the air chamber M, communicating with the longitudinal pneumatic channel M^1, which opens into the large valve-throat M^2. This valve-throat is commanded by the large disc-valves N and N^1, held the required distance apart upon the valve-stem N^2. The upper valve N opens and closes the orifice of the valve-throat in the compressed-air chamber O, while the lower valve N^1 opens and closes the orifice of the throat in the open air. By the upward and downward motion of these disc-valves, the pneumatic channel M^1 and the chamber M are alternately charged with compressed air or action-wind, and placed in communication with the open air, into which they exhaust.

We now come to the pneumatic appliance immediately commanded by the thumb-piston. A Transverse Section of this appliance is given in Fig. CCLIII., directly under the large disc-valves above spoken of. P is the valve-box, formed by the bottom Q, the side Q^1, and the top Q^2, bored with the valve-throats and ducts as indicated, and closed in front by the movable board Q^3. At T is shown the end of the pneumatic tube, which extends from the pallet-board of the commanding thumb-piston,* and communicates with the duct S and the interior of the small primary pneumatic or motor-bellows R. Attached to the movable board of this bellows is the valve-stem R^1, carrying the twin disc-valves V, which command the interior and exterior orifices or ports of the duct U. This duct communicates with the interior of the large secondary pneumatic W, in the manner indicated. From the movable board of this bellows rises the wire X, which passes through a brass plate, and is screwed into the small cylindrical piece of wood X^1, the upper end of which receives the free end of the valve-stem N^2, but does not bind it in any way. At the right-hand end of the illustration is shown the portion of the action which commands the orifices of the pneumatic tubes, which communicate with the draw-stop pneumatic appliance adjoining the distant wind-chest. One of these pneumatic tubes is shown at 3, communicating with the duct in the tube-bar F^1. The square, vertical rod F, which is held in position by the two registers 1 and 2, is clothed with felt and leather on its lower end, forming a valve to the orifice of the duct in the tube-bar F^1. When the draw-stop trace C is moved, either by hand or by the combination action, its inclined end E enters a slot cut in the vertical rod F and raises it a short distance, uncovering the orifice in the tube-bar F^1, and allowing the compressed air in the pneumatic tube 3 to exhaust into the atmosphere. The rod Z belongs to either a crescendo or a sforzando foot-lever. It actuates the roller Y, which carries the fan Y^1. This fan, in moving upward, engages, one after the other, the projecting pins shown at F^2, lifting the valve-rod F and all

* The reader will find the thumb-piston action which commands this combination valve-box fully shown at T in Fig. CCXLVIII. When the piston is pressed in, it pushes the attached pallet from the face of the pallet-board, and uncovers the orifice of the duct therein, which receives the near end of the pneumatic tube extending thence to the combination valve-box illustrated in Fig. CCLIII., and described above. The moving of the pallet simply allows the compressed air in the pneumatic tube to exhaust into the atmosphere. When the piston is released the pallet again closes the pneumatic duct.

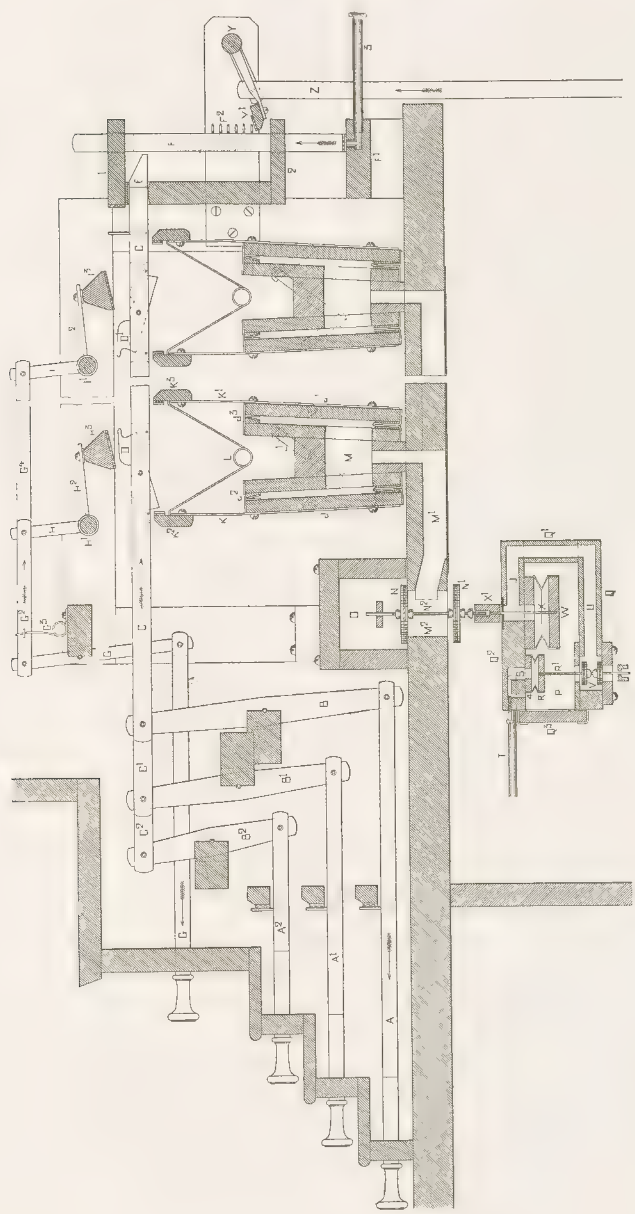


Fig. CCLIII.

similar rods, belonging to the special draw-stop action, in any desired order, according to the positions of the pins in the several rods. This forms a crescendo or sforzando action of remarkable simplicity and efficiency.

Having pointed out in detail all the component parts of this adjustable combination action, it is now only necessary to briefly describe its general operation. When the performer desires to set any combination of stops on a certain thumb-piston,—say on the piston No. 1, which commands the fans K^2 and K^3, Fig. CCLIII.,—he first draws all the desired stops (seeing that all others are put in), and in doing so he moves the traces in the direction indicated by the arrow on the trace C, until the left hand portions of all the adjustable catches are brought directly under the transverse setting-bar H^3. He now pulls the knob of the rod G, moving the upper setting-rod G^2, and depressing the setting-bar H^3. This operation places all the adjustable catches in the drawn stop-traces in the position indicated at D, and all those in the stop-traces that are undrawn in the opposite position indicated at D^1. On releasing the setting-knob, the setting-action returns, under the force of the spring G^3, to the inoperative state shown in the illustration. The performer now puts in all the draw-stop knobs, and then proceeds to set another combination on thumb-piston No. 2 in a similar manner; and so on until all the required combinations are set. As each thumb-piston has a special fan movement and setting-action, none of the set combinations are interfered with by subsequent operations. It will be realized, on referring to Fig. CCLIII., that all the undrawn stop-traces that have their adjustable catches in the position shown at D, will be drawn by the closing motion of the fans, while all those undrawn traces which have their adjustable catches in the reverse position shown at D^1, will remain unaffected by the closing motion of the fans. On the other hand, the traces of all stops that are drawn, which have their adjustable catches in the position shown at D, will remain unaffected by the closing fans; while those which have their adjustable catches in the position indicated at D^1, will be moved by the corresponding fans so as to silence the respective stops. It now only remains for us to trace the pneumatic action which obtains from the pallet of the thumb-piston to the power-bellows which operate the fans. In the valve-box P all the movable parts are shown at rest, or in the positions in which they remain as long as the thumb-piston is untouched. The compressed air passing through the small feed-duct 4 and the duct S into both the pneumatic tube T and the small primary pneumatic R, has filled them, and instituted a state of equilibrium in the latter; allowing the weight of, and the pressure of the compressed air on, the disc-valves V to expand the pneumatic, and close the exhaust-port of the duct U. The compressed air passing through the supply-port and the duct U, has filled the secondary pneumatic W, and instituted a state of equilibrium; allowing its movable board to fall, drawing down the cylindrical piece X^1, and permitting the large disc-valves N and N^1 to assume the positions shown, placing the interiors of the power-bellows J and J^1, the chamber M, and the pneumatic channel M^1 in communication with the open air. Under these conditions everything remains at rest.

Now, when the thumb-piston is pushed in by the performer, the adjoining end of the pneumatic tube T is opened to the external air: the primary pneumatic R

exhausts through this tube, and is instantly collapsed by the pressure of the air in the box P; the disc-valves V are drawn upward, closing the supply-port and opening the exhaust-port of the duct U. The large secondary pneumatic W now exhausts through the duct U, and is forcibly collapsed by the compressed air in P, moving upward the cylindrical piece X^1, and reversing the positions of the disc-valves N and N^1. The compressed air in the chamber O now rushes under the upper, raised valve N, into the valve-throat M^2, and thence through the channel M^1 into the chamber M and the interior of the power-bellows J and J^1. The bellows are forcibly expanded and their fans moved toward each other, completing the pneumatic action, and operating the remaining portion of the combination action in the manner previously described. On the release of the thumb-piston, the pneumatic tube T is closed, the compressed air again fills the primary pneumatic R, through the feed-duct 4, and immediately every movable part returns to the state of rest indicated in Fig. CCLIII.

Patents for adjustable combination actions have been taken out by certain English organ builders; but owing to the extremely crude and insufficient character of the drawings appended to the Patent Specifications, and our not having been favored with any special assistance from the patentees, we cannot venture to give any illustrations of these actions. We shall, accordingly, give only brief extracts from the more important Specifications, and a few remarks on the inventions alluded to.

In the year 1889, Messrs. Brindley and Foster, Organ Builders, of Sheffield, Yorkshire, took out a patent for an adjustable tubular-pneumatic combination action.* In the preamble of the Specification the inventors say:

"The object of this invention is to enable the organist to bring any desired combination of stops on any particular piston or pedal, without occupying extra room in the console, and we accomplish this by means of a pneumatic combination of valves, bellows, and their auxiliary parts, with great rapidity and certainty. The organist makes the desired combination by drawing out the stops, and then by means of a small lock-knob conveniently placed, that particular combination is locked in connection with a corresponding piston, or with a pedal, as long as the lock-knob before mentioned is drawn.

"In carrying out our invention we place a compressed-air chamber immediately behind the draw-stop jamb, containing for each draw-stop, and connected thereto, two separate oblong bellows placed vertically, and having fixed between them an enclosed double-acting valve, actuated by, and communicating with, the said bellows. The top or expanding end of each bellows is attached to the bar of the draw-stop, and they are so arranged that as one expands the other contracts and *vice versa*, this action being caused by the admission of air into one bellows, and exhausting the other, and thus the draw-stop is moved in or out as the case may be. The bellows are filled or exhausted by means of double-acting valves, controlled by two circular bellows (1) to which they are connected. When one of the circular bellows (1) is inflated with air admitted through air-tubes by apparatus hereafter described, it raises the valve in connection with it, opening the exhaust to the corresponding oblong bellows which is immediately closed by the pressure of wind in the surrounding chamber; this action of the bellows opens the double-acting valve previously mentioned as being fixed

* "A New System of Interchangeable Composition Action in Organs to Change and Adjust any Desired Combination of Stops." English Letters Patent No. 16,362. Applied for Oct. 17, 1889. Accepted Aug. 23, 1890.

between the oblong bellows, and exhausts the other circular bellows (1) causing its valve to drop and admit air from the chamber into the other oblong bellows; all these movements are simultaneous.

"We construct the locking mechanism as follows: we form a chamber to which compressed air may be admitted through a valve operated by one of the small locking-knobs before mentioned; this chamber communicates through openings facing each other with two circular bellows (2) which actuate two valves in connection with another air chamber, and also with the air tubes leading to the circular bellows (1). The openings which face each other are made large, and may be closed and opened alternately by a valve working between them, and which we call the locking-valve; upon the same valve-pin, in a space outside the chamber, we fix exhaust-valves to exhaust each bellows (2) alternately. These exhaust-valves and the locking-valve may be worked in either direction by two small bellows (3) attached to the ends of the valve-pin, and communicating by air tubes with the oblong bellows and draw-stops. Thus when the draw-stop is pulled out, one of the bellows (3) is inflated and pushes the locking-valve over to the opposite side; when the draw-stop is pushed in, the opposite bellows is inflated and moves the locking-valve over in the contrary direction.

"When, however, compressed air is admitted (by pulling out the locking-knob) into the locking-valve chamber, the pressure upon the larger surface of the locking-valve renders it superior to the bellows (3) and, therefore, prevents any alteration in the bellows (2) or their valves, until such superior pressure is removed by pushing in the small locking-knob, which opens the exhaust.

"The air chamber before mentioned as being connected by means of air tubes to the circular bellows (1) and the valves controlled by bellows (2) is supplied with air by means of a valve opened by touching the corresponding piston; the air so admitted passes through one or other of the tubes to the circular bellows (1) thereby exhausting one of the oblong bellows and throwing the draw-stop either on or off, as it was adjusted when the locking-knob was drawn out."

This adjustable combination action is certainly ingenious, but it is somewhat complicated on account of the number of bellows, valves, and other moving parts it embraces.

In the year 1891, Mr. J. J. Binns, Organ Builder, of Bramley, Yorkshire, took out a patent for an adjustable combination action.* In the preamble of the Specification the inventor says:

"The object of my invention is to form any combination of stops the organist may wish upon the different combination pistons or pedals, and by use of the 'hitch' pedal the organist can set or lock any such combination of stops which will remain set or locked until altered."

This action is characterized by the free use made of the slide-valve. The slide-valves are introduced in the adjusting and setting-action; and they are actuated by diaphragm-pneumatics, and are secured in their adjusted positions by means of a pneumatically-operated bar, which, when lowered, fits into notches cut in their upper surfaces. The bar is commanded by a small power-bellows moved by the hitch-pedal pneumatic. The diaphragm-pneumatics, which move the slide-valves, are connected by means of tubes with the draw-stop combination-box. This

* English Letters Patent, No. 12,087. Applied for July 16, 1891. Accepted Sept. 5, 1891. Drawings very unsatisfactory.

is the only adjustable combination action known to us in which the slide-valve forms the characteristic feature.

Messrs. Wilkinson and Sons, Organ Builders, of Kendal, Westmoreland, have invented and successfully introduced in their Organs an extremely ingenious adjustable combination action which presents certain unique features. In a communication to us, accompanied by drawings, the inventors say: "Unlike all other interchangeable arrangements we know of, our action is not encumbered by any exterior accessories, such as combination stops, stop-keys, rocking levers, auxiliary pedals, turning-round draw-knobs, etc. The organist has only the ordinary form of draw-stops and combination pedals to deal with. In order to disconnect a pedal from the combination to which it was previously adjusted, it is only necessary to impart an upward movement to the pedal by placing the toe under it (a few ounces pressure and about one inch of travel being sufficient): the foot is then withdrawn, and the pedal falls to its normal position, when it is ready to have a new combination set on it.

"The combination of stops which is to be set on the pedal is now drawn in the usual manner by the organist, and the pedal is pressed down by his foot, and immediately allowed to return to its normal position. This simple movement sets the combination on the pedal, and it will subsequently be brought on whenever the pedal is depressed, until again released by the small upward movement of the pedal as first described. There may, of course, be any desirable number of such adjustable pedals, their actions being quite independent of each other. The draw-stop knobs are free at all times to be moved by hand without in any way interfering with the combination action. As the combination action moves the stop-knobs, the organist can see the results of his operations. The action is so arranged that any possible combination or solo voices can be set on any pedal."*

In the year 1894, Mr. Charles Frederick Brindley, Organ Builder, of Sheffield, Yorkshire, took out a patent for a combination action,† which presents certain unique features. The inventor speaks of his appliance in the following words:

"The object of my invention is to enable the performer to give expression by means of composition [*sic*] pedals, and for the more rapid transition of the combinations; also for obtaining greater control by one movement of the foot. . . .

"By means of this invention, the full Great, Swell, and Pedal Organs, with their couplers or any portion thereof, may be more economically attached to any one pedal. The performer may also arrange the draw-knobs for solo work, then add any combination with the pedals and return to the solo without altering the draw-stop arrangement, by one movement of the foot each time. This change of combination is produced in one-fourth the movement of the pedal, hence the performer may, by slightly moving the pedal controlling any louder effect give 'expression' by producing a momentary crescendo effect for a single beat or

* Although Messrs. Wilkinson and Sons have placed in our hands complete drawings of this ingenious adjustable action, we do not feel at liberty, as their invention does not seem to be protected, to place its details before the whole organ-building world through the medium of our pages. But as Messrs. Wilkinson are courtesy personified, any genuine student of the art of organ-building can readily obtain full particulars direct from them, or personally inspect their actual work, just as we have had the privilege of doing.

† "A New Method of Obtaining Combinations of Organ Registers by Pneumatic and Mechanical Means." English Letters Patent, No. 12,711. Applied for June 30, 1894. Accepted Nov. 17, 1894.

more continuously. I also place prominently in view of the performer a series of 'indicators,' one of which will correspond with, and be controlled by, one of the pedals instead of actuating the draw-knobs. The indicators may have the abbreviated names of the stops which are controlled by the corresponding pedal marked upon them, or any indicating letter or the like. They may be advantageously placed over the Swell clavier, thus enabling them to be seen at a glance [by the performer], without having to turn the head to examine the draw-stop knobs, or withdrawing the attention from the music.

"Immediately behind the knee-board I place an automatic catch, which holds the pedal in position when pressed to the bottom of the slot in the knee-board, it being so constructed that a pedal already held down, by the catch engaging with a projection from the side of the pedal, will be released by the action of another pedal subsequently pressed down, the catch being forced forward by another similar projection upon the pedal last used acting upon the inclined part of the catch. The pedal so released is immediately raised to its normal position by the action of a spring. It will thus be understood that one pedal only can be held down at a time, and that the said pedal may be instantly released by pressing back the catch by means of the toe-piece.

"Suppose in any Specification of an Organ to be built two or more composition [*sic*] pedals are specified, their working uses may be described as follows: Suppose the stops to be acted upon be 4, or more in number, and let the numerals 1, 2, 3, 4, represent such stops. The depression of the first pedal would bring in action 1 and 2, indicating the same on the indicator. The second [pedal] would have associated with it, say stops 1, 2, 3, 4, and would act in like manner, and so on with as many pedals as were included in the Specification.

"The crescendo effect would be used in the following manner: Suppose 1st pedal in operation, and the player desires a temporary increase of tone, he can by partially depressing and letting his foot dwell on No. 2 pedal obtain the effect of the stops associated with the second pedal, and on removing his foot, this 2nd pedal, resuming its position of non-operation, allows only the combination of stops associated with No. 1 pedal to be in action."

It will be understood from the above description that the action is not directly adjustable; and that the use of inscribed indicators practically involves permanent combinations on the pedals or foot-levers. Herein lies the inherent weakness of the action; but as a fixed combination appliance it is highly suitable for small Organs. While the diagrams appended to the Patent Specification illustrate to some extent the details of the action, they are totally insufficient for the standard we have set for the illustrations in the present work.

Several other combination actions, adjustable or fixed, have been invented by English organ builders, but as these present no features of special interest or importance, we have not considered it advisable to occupy valuable space by describing them.

THE VENTIL SYSTEM.

The insufficient substitute for the true adjustable combination action which has been favored by the French organ builders is that commonly known as the ventil system or action. In this system the stops belonging to any division of the Organ are arranged in two groups, designated *Jeux de fond* and *Jeux de mutation*. These groups are planted on a longitudinally divided wind-chest, furnished with separate pallet-boxes and pallets, and having distinct wind supplies com-

manded by ventils. Any combination of stops drawn in these groups will sound only when the foot-levers for opening the wind-ventils are depressed. Further information may be given in the words of France's greatest organ builder—the late Aristide Cavaillé-Coll:

"Les sommiers seraient établis d'après notre nouveau système à doubles layes de soupapes; l'une de ces layes alimente les jeux de fond, l'autre les jeux de mutation et les jeux d'anches. De cette manière les deux séries de jeux peuvent sonner ensemble ou séparément sans altération possible. Ces doubles layes donnent lieu en même temps à l'application de notre nouveau système de pédales de combinaison. . . .

"Ces pédales de combinaisons diffèrent essentiellement de ce qui avait été fait d'analogue dans les orgues anglaises et allemandes; on trouve en effet dans ces instruments certaines pédales de composition [*sic*] destinées à appeler ou à supprimer divers mélanges de jeux préparés à l'avance par le facteur de l'instrument et qui se reproduisent toujours de la même manière. . . .

"Nos nouvelles pédales de combinaison ont un tout autre résultat; elles laissent à l'artiste la faculté de grouper ses jeux comme il l'entend et d'appeler avec la même pédale toutes les combinaisons relatives au nombre de jeux correspondants à chaque groupe; ainsi, par exemple: un groupe de six jeux peut être combiné de 63 manières différentes et appelé par une même pédale. Un groupe de dix jeux donne 1,023 combinaisons. Un groupe de douze jeux 1,613. Un groupe de vingt jeux donne 1,047,369 combinaisons.

"Ces quelques exemples suffisent pour faire comprendre les avantages des pédales nouvelles de combinaison comparées aux anciennes, puisque chacune d'elle peut opérer au lieu d'un seul mélange autant de combinaisons que la comporte le groupe de jeux sur lequel elle agit, et qui, pour un groupe de vingt jeux, dépasse le chiffre d'un million de combinaisons."—"Projet d'Orgue Monumental pour la Basilique de St.-Pierre de Rome": 1875.

When M. A. Cavaillé-Coll wrote the above he was acquainted only with the ordinary fixed combination action which obtained in the English school of organ-building; and, in all probability, such a thing as an adjustable combination action had never entered his mind. It was about seven years later before the first adjustable action was placed in an Organ by the late Mr. Hilborne L. Roosevelt. It is only right to say that the French ventil system has some marked advantages over the ordinary old-fashioned fixed combination action, but it has several obvious shortcomings. Both the ventil system and the fixed combination action are totally insufficient for modern requirements, and should now be classed among the curiosities of old-time organ-building.

CRESCENDO ACTION.

The crescendo action is designed for the purpose of gradually increasing the tonal power of the Organ by the progressive addition of stops in suitable order. The German organ builders appear to have been the first to invent and use a complete crescendo action; employing for the purpose a revolving drum, having a spirally disposed, raised portion on its surface, against which a series of small wheels, inserted in the ends of lever arms, rest, and are raised or lowered in succession as the drum revolves. The lever arms are connected in some suitable manner with the draw-stop action. The drum is made to revolve by being con-

nected by a band or chain with a wheel placed in some convenient position immediately above the pedal clavier. The wheel has a roughened surface, and is turned in either direction by the foot of the performer. Two crescendo appliances of this description are to be found in the Organ in the Thomaskirche, at Leipzig, constructed by Mr. W. Sauer.

The crescendo action is of questionable value; and when introduced it should act only on some more important division of the Organ. Should crescendo actions be desired on more than one division, they should be operated independently of each other and by the motion of foot-levers.

In the pneumatic adjustable combination action illustrated in Fig. CCLIII. is shown a very simple and efficient crescendo action. The vertical rod Z is attached at its lower end to any suitable movement connected with the crescendo foot-lever. When moved in the direction indicated by the arrow, it causes the roller Y to turn and raises the fan Y^1. The fan first lifts the vertical valve-rod F by engaging the lowest of the projecting pins, indicated at F^2, which belongs to it. Then, it subsequently lifts the other valve rods in the order in which their pins are inserted, producing a regular *crescendo*. As the rod Z is lowered, the fan Y^1 allows the valve rods to drop in their proper order, producing a regular *decrescendo*. Each valve-rod, belonging to a separate stop, is bored with several holes, short distances apart, to allow its pin to be inserted where deemed desirable. The pins have looped heads and split, spring shanks; the latter holding them firmly in the holes in the valve rods.

SFORZANDO ACTION.

The sforzando action which has commonly been inserted in Organs is simply a movable coupling action, which, on the depression of the sforzando foot-lever, instantly reinforces the strength of one manual division by coupling another division to it. It usually coupled the Great division to the Swell division; but it can be arranged, in a large Organ, to temporarily reinforce the tone of any division by adding the tones of any other series of stops to it. In some English Organs in which the Swell division was provided with sub and octave couplers acting on itself, the sforzando action temporarily brought these couplers into operation. This was a most inartistic and objectionable expedient, simply because it added nothing to the unison tone, while it entirely upset the tonal balance of the combination drawn. To show how little the science of tonal appointment has been understood even by distinguished organists, we may quote the following words from the pen of the late Dr. E. J. Hopkins: "In a few instances, where the Swell has been provided with octave and double couplers, the sforzando pedal has been made to bring on those couplers simultaneously, and not act on the Great Organ; and where the Swell is to CC, and is powerful, this kind of movement is in some respects more effective than the other, as the *reinforcement* is under the influence of the Swell." It is surprising how the love for powerful sounds in the Organ, obtained at any sacrifice of tonal balance and refinement, pervades the organ-playing world. Noise, not Music, is the path to fame!

CHAPTER XXXIII.

WOOD PIPES: AND THE MATERIALS USED IN THEIR CONSTRUCTION.

PIPES constructed of wood form a very important section of the sound-producing portion of the Organ. This fact was fully realized by the great masters of organ-building, and notably by the renowned Schulze, of Paulinzelle; but of late years there has appeared a general disposition among organ builders to use them very sparingly. The causes which apparently have brought about this undesirable neglect are, however, unworthy of serious consideration by the artistic builder, in comparison with the tonal advantages which attend the proper introduction of wood stops. The causes may be summarized as follows: In the first place, wooden pipes are more troublesome to make and voice in an artistic manner than ordinary metal ones; and when carefully constructed of proper materials, they cost as much, if not more. In the second place, more time and trouble are demanded in their proper tonal regulation. In the third place, wooden pipes require more room than metal ones, and, accordingly, larger and more expensive wind-chests are necessary, when they are used in proper proportion. In the fourth place, the Organ which contains wood stops, requires more attention in the matter of tuning; and the organ-builder who contracts for the tuning, naturally aims at doing the least possible amount of work for his yearly commission. And, in the fifth place, a common opinion exists—doubtless because "the wish is father to the thought"—that better tones are to be obtained from metal than from wooden pipes. It will be realized from the above, that the modern neglect of wood stops springs chiefly from the organ builder's desire to save himself as much labor and money as possible, and, in a lesser degree, from the parsimony of the purchaser, who expects more for his outlay than he can reasonably demand. These two causes are at the root of a great many of the shortcomings of modern organ-building.

The characteristic and desirable tones of wood pipes cannot be produced from metal pipes, although it is true that in certain qualities of flute-tone a very close imitation can be arrived at, so much so that it is quite allowable, in some special stops, properly constructed of wood, to have their higher octaves of metal. Nothing, however, is gained by such a proceeding, and we do not recommend it. The great value of wood-tone, so to speak, is its mixing and thickening properties; and in a large Organ this becomes evident to the musical ear. In the Chapter on the Concert-room Organ, we have, in speaking of the Willis Organ in the Royal Albert Hall, London, specially commented on the inartistic practice of omitting wood stops, and the builder's views on the subject.

Too much care cannot be exercised in the selection and treatment of materials for the construction of the wood pipes of the Organ, and especially those which compose the smaller and more delicate-toned stops. Only the finest quality of wood should be used, and every precaution must be taken to have it thoroughly seasoned. Steamed or stove-dried wood should in all cases be rejected, because under the action of steam or dry air of a high temperature, the wood becomes altered in its nature and considerably injured. The wood for pipes should be seasoned naturally under cover; and the planks, sawn to the proper thicknesses for the different sizes of pipes, should be so stacked as to allow the air to circulate freely on all sides of them. For pipe-making the wood cannot be too old provided it has been kept under cover and otherwise properly cared for. Wood freshly sawn should never be used. Should there be any question about the dryness of the wood when taken from the seasoning shed, it will be desirable to cut out all the pieces necessary for the stop, roughly dress them to about the required thickness, and then open-stack them in some higher part of the workshop, where they can get all the dry air that is going. A week or so will be sufficient to bring the wood into a suitable condition for further treatment and gluing-up.

In ordinary books on the art of organ-building and in written specifications considerable stress is laid on the qualities of metal to be used for pipes, while the equally important question respecting the kinds and qualities of wood to be used for pipes is passed over, or touched upon in some general and indifferent fashion. It would seem that there is a general impression amongst writers that the woods for organ pipes may be safely left to the tender mercies of the organ builder. But as there are bad as well as good woods for this as for other branches of organ construction, careful instructions ought always to be given in specifications for new instruments, even if they are not thought necessary in text-books on organ-building. We venture to break this long established silence, and consider it advisable, in a treatise like the present, to give the following brief particulars respecting the woods best suited for the construction of the different parts, and the several classes, of wood pipes.

White Pine (*Pinus strobus*).—This valuable North American wood is unquestionably the best for all-round use in pipe-making, or for all those portions in which hardwood is unnecessary. It can be obtained perfectly free from knots and other blemishes, in planks of sufficient dimensions to form the sides of the largest pipes required for the Pedal department of the Organ. Logs of fine quality are

shipped at Quebec of lengths from 30 to 60 feet. Only the finest quality of deals, or those known as "brights," should be sawn into boards for pipe-making, or at all events for pipes from the 8 ft. octave upward, inclusive. The boards should be sawn of the following thicknesses: 1½ in., 1¼ in., 1⅛ in., 1 in., ⅞ in., ¾ in., ⅝ in., ½ in., and ⅜ in. All necessary intermediate and thinner sizes can easily be dressed from these. It is economical to have wood sawn to close upon the finished thicknesses; and it materially aids the perfect seasoning and natural drying of the boards. As pine of the best quality, absolutely free from blemishes, can be readily obtained, there can be no excuse on the part of the organ builder for the use of an inferior wood, or one having the indication of sap-wood, a knot, or any other imperfection. This wood is light, soft, easily worked, and glues well. When freshly cut, it is of a pale straw color, but becomes considerably deeper in tint, inclining to a brownish-yellow, when properly exposed to light and air in seasoning. The annual rings are not distinctly marked; but their direction, indicating the manner in which the deal has been cut from the tree, can be easily traced. The direction of the annual rings in the softer pipe woods, and indeed in all classes of wood, is a matter of some importance. In the most suitable boards the rings pass almost directly through their thickness, in the manner indicated at A in the accompanying diagram, Fig. CCLIV. Boards having the rings running as indicated at B, are inferior, and should not be selected for fine pipe-making. The proper quality has

Fig. CCLIV.

a clear, silky surface when newly planed, and commonly shows short detached, hair-like streaks, running in the direction of the grain. "First quality brights," having the annual rings as indicated at A, should alone be used for the more delicate classes of pipes. On no account should the very inferior qualities of deals, known as "dry floated" and "floated," be employed in fine work, although few pipe makers are particular in the matter of wood.

White pine is properly used in the construction of the main portions of all the quadrangular pipes of the Pedal Organ; for the quadrangular tubes of certain reed stops of 32 ft. and 16 ft. pitch; for the pipes of the manual Bourdons, Lieblichgedeckts, and those of almost all the quadrangular stops of the flute species, in association with other and harder woods, as hereinafter mentioned.

Sugar Pine (*Pinus Lambertiana*).—This tree grows to an immense size in the Pacific United States, and from its habit it is sometimes called "giant pine." Trees occasionally reach the height of 275 feet. Its wood is light, soft, and straight-grained, closely resembling white pine, though it is generally considered less valuable. Owing to the large size and perfect character of the planks sawn from this tree, the largest pipes that can possibly be required in the Organ may be

readily formed from them. The wood is easily dressed and has a fine silky surface. While suitable in every respect for the larger pipe-work, we much prefer the finest white pine or spruce for small pipes. Sugar pine is admirably suited for the general structural work of the Organ, and when cleanly dressed and varnished it has a fine appearance.

SPRUCE-FIR.—This handsome tree, of the genus *Picea*, as grown in the Adirondacks, in the State of New York, furnishes wood in every way suitable for the highest class of wood pipes. The finest quality comes into the market as "piano sound-board wood," in planks of small dimensions and 5/8 inch thick. It is cut with the annual rings as nearly as possible at right angles to the faces of the planks; and its grain is singularly straight and regular. It dresses with a beautiful silky surface, and has a fine appearance when varnished. It is easily worked, glues well, and is in all essentials perfectly satisfactory under manipulation. Its only objection, in the opinion of the organ builder, is its comparatively high price; but this should not prevent its adoption for the smaller and more delicate classes of pipes, having a clear and crisp intonation. It is especially suitable for the wood pipes of true Chamber Organs, and is to be recommended to amateur organ builders, who desire to produce exceptionally good work, and who take a delight in the good appearance as well as in the fine tone of their pipes. As the thickness of the sound-board spruce, when dressed, is only about a full half-inch, pipes of more than 4 ft. speaking length cannot well be made of it. This is an ample thickness, however, for small-scaled pipes, of 4 ft., because the wood is much firmer than ordinary white pine. If there is anything in the wood of which pipes are made affecting the tones produced, this sound-board spruce must occupy the highest rank, for not only does it play an important part in piano construction, but the most important part in the formation of the whole family of orchestral stringed instruments is of this wood. In England the wood is known as "Swiss fir," being imported from Switzerland, in the usual sound-board form of small thin planks or boards.

There are several other varieties of fir and soft woods of which pipes can be made, but those above named are the most suitable and generally useful.

YELLOW POPLAR (*Liriodendron tulipifera*).—This variety of poplar, commonly known as "white-wood," is used to a considerable extent by American organ builders for the larger pipes of the Pedal Organ; and to the construction of these it certainly should be confined, being very inferior to white pine and sugar pine of the proper quality. The color of the wood varies somewhat, but it may be described as a yellowish- or brownish-white; and the annual rings, being slightly darker on one side than the other, are easily distinguished. The best quality of this wood is uniform in texture, and when thoroughly seasoned for not less than two years, it can be safely used for large work. When kept dry, it may be considered a durable wood, and after proper seasoning, and under ordinary atmospheric conditions, it is not very liable to warp, swell, or shrink.

SEQUOIA or REDWOOD (*Sequoia sempervirens*).—This valuable wood is well suited for the construction of large pipes, and has been used for this purpose by certain English builders. The sequoia grows to an immense size, and planks for pipes of 32 feet speaking length can readily be obtained, free from knots or other

blemishes. The wood is straight-grained and of a brownish-red color, and is easily worked, taking a fine finish from the plane. The annual rings are boldly marked by dark margin lines, which latter impart a rich appearance to the dressed faces of the planks. Carefully finished and varnished pipes of this wood would have a handsome appearance. Under all ordinary conditions this wood can in every way be relied upon, while its moderate price in the open market should commend it for use in large pipes.

SYCAMORE (*Acer pseudo-platanus*).—A common tree, yielding a clean, close-grained, white wood, which could be used with advantage for certain classes of pipes of large scale. It works cleanly under the plane and glues well. It does not seem to have been used to any noteworthy extent by organ builders, but it deserves recognition.

JARRAH (*Eucalyptus marginata*).—A tree which grows abundantly in South-western Australia. It is also known as the "mahogany gum-tree." Jarrah wood is famous on account of its practical indestructibility, not being attacked by the wood-destroying insects. It is of a reddish color, heavy, and close-grained, easily worked, and receiving a high finish under the plane. These important and desirable properties render it very suitable for fine pipe-work; and especially for pipes whose walls have to withstand the extreme vibration generated by the action of wind of high pressures. It is very suitable for the pyramidal tubes of certain reed stops. We strongly recommend this plentiful and fine wood to the attention of artistic organ builders.

CHERRY (*Prunus*).—This wood, as commonly used in the United States, is admirably suited for the construction of the finest description of wood pipes. It is close and straight-grained, easily worked and takes a good finish under sharp tools, and glues well. It may advantageously be employed for CONCERT FLUTES, HARMONIC FLUTES, and all small-scale stops of string-tone or of other special character. It is to be recommended for the fronts of pipes of the 4 ft. and higher octaves, otherwise made of white pine or spruce, and especially for those having inverted mouths; and likewise for the mouth pieces, caps, etc., of larger pipes. This valuable wood has been so largely used for ordinary joinery in the United States that it is likely to become scarce and expensive.

PEAR (*Pyrus communis*).—Pear-tree wood is harder and closer-grained than cherry, but is suitable for all the purposes above enumerated and recommended for that wood. German organ builders have used pear-tree for special classes of pipes, especially those for mechanical organs. We have met with very beautiful stops of this admirable wood, both of string- and flute-tone. Pear-tree, owing to its compact and extremely fine grain, can be used much thinner than any of the woods before described; and this fact recommends it for the wood stops of Chamber Organs, in which the most delicate tones are desirable and space is valuable. It is susceptible of the highest possible finish, so much so that it ranks second to box for wood-engraving and turnery. It is too scarce and expensive for anything approaching general use in organ-building.

CEDAR (*Cedrela odorata*).—The West Indian or ordinary red cedar may be considered, so far as pipe making is concerned, a poor edition of bay-wood; but it

rather takes the place of white pine than of mahogany. We have made both a GEDECKT, 8 FT., and a FLAUTO D'AMORE, 4 FT., entirely of cedar, with a perfectly satisfactory result. Only the hardest and closest-grained kind should be used by the pipe maker.

WHITE MAPLE (*Acer dasycarpum*).—This graceful, fast-growing tree of good size, which grows wild in Eastern North America, yields a close-grained wood of a warm white color, the annual rings of which are clearly marked. When properly cut and thoroughly seasoned, it is admirably suited for pipe-making. Small-scale pipes of the CONCERT and HARMONIC FLUTES may, with great advantage, be made entirely of white maple, the weight and firmness of the wood rendering it unnecessary to use thick material. For the 2 ft. pipe of these stops, wood finished to $\frac{3}{16}$ inch full is sufficient.

SUGAR MAPLE (*Acer saccharinum*).—Like the white maple, this hardwood is highly suitable for first-class pipe-work. From its peculiar figure it is commonly known as "bird's-eye maple," and is ranked as an ornamental wood. The late Mr. Roosevelt presented the writer with a MELODIA, the pipes of which were of white pine, fronted with choice bird's-eye maple, and capped with beech. The stop had a very handsome appearance, being carefully finished and varnished. It is quite useless to recommend such wood, cheap as it is, to the ordinary organ builder, for he cares very little about the appearance and finish of his wood pipes, so long as they pass muster in the matter of tone.

TOON (*Cedrela Toona*).—This is another Indian wood worthy of the organ builder's attention. The tree grows plentifully in Bengal and other districts of India; and it is also abundant in Queensland. It grows to an immense size, a single tree having been known to yield 80,000 feet of fine lumber. The wood somewhat resembles mahogany, and is light and durable, non-resinous, and is not attacked by insects. It takes a high finish, being much used for furniture and fine joinery. Its properties render this wood very suitable for work destined for tropical countries; for although not so good as teak it is superior to mahogany in this direction.

MAHOGANY (*Swietenia mahagoni*).—The different kinds of mahogany are largely used by high-class organ builders, but not in pipe-making generally. Mahogany is exceedingly durable; it shrinks very little, warps and twists less than any other wood, works easily when straight-grained, and glues well. In fact it has only one drawback—its costliness. The best variety of mahogany, for pipe bodies, or for the fronts and caps of pipes otherwise made of some soft wood, is straight-grained and uniformly-colored Honduras or bay-wood. For small pipes the hardest and closest-grained wood should be used.

Spanish mahogany is distinguished from Honduras by a greater weight and solidity, and by a white, chalk-like substance which fills its pores. When "plain" or straight-grained it makes beautiful fronts for pipes. We have made FLUTE stops, both ordinary and harmonic, the pipes of which are fronted and capped with Cuba mahogany, and their tones are singularly pure and bright. Their mouths are inverted.

Like all the other pipe woods, mahogany is best adapted for pipe fronts when

its annual rings are as nearly as possible at right angles to the faces of the boards, and its grain runs clear and practically straight.

Black Walnut (*Juglans nigra*).—This is a wood which in pipe-making answers all the purposes of mahogany, and might, with advantage, be used much oftener than it is. It has, however, been consumed to so great an extent in the United States for all classes of common furniture and joinery, that it has become scarce and about as dear as good mahogany. When straight-grained and perfectly dry it dresses well, leaving the plane with a firm, silky surface; and it glues in a perfectly reliable manner. Pipes made of white pine or spruce with fronts and caps of walnut, carefully finished with shellac varnish, have a very good appearance. Displayed pipes with fronts of walnut may receive stenciled decoration, in gold and colors, directly on the surface of the natural wood; the dark brown color of the wood furnishing a good background.

Oak (*Quercus alba*).—Of all the hard woods that have been employed in pipe-making, oak seems to occupy the first place. It was frequently used by the old Continental and English organ builders for certain classes of stops. It appears to have been a favorite with Father Smith, who not only selected the finest quality of "wainscot" he could procure, but took more pains in the construction of his pipes than probably any English builder has taken since his day. Snetzler, the organ builder, informed Dr. Burney that he had watched Father Smith at work; and had observed that he was so careful in the selection of the wood for pipes as to reject every piece that showed the slightest flaw or knot of any kind. Besides this, he was so thoroughly an artist, as never to hesitate in throwing aside a pipe which did not please his critical judgment, making another which should be free from any liability of failure. In his "Schedule" of the contents of the Temple Church Organ two Gedeckt stops of "Wainescotte" are mentioned for the Great and Choir Organs; and in the "Ecchos" two Gedeckts of "Wood" are provided. This shows, what we know to be a fact, that Father Smith only used oak for certain stops, probably with the aim of producing a special quality of tone.

There is little likelihood of oak being used for the bodies of pipes by professional organ builders at the present day, either at home or abroad, except under some very special circumstances: but it may be used with great advantage for the mouth pieces of the large pipes of the Pedal Organ, and also for their caps and feet. In all cases and for all purposes it should be selected with a straight grain, thoroughly seasoned, and perfectly dry. Under these conditions oak works well under sharp tools, and glues well. Quartered oak forms beautiful fronts for displayed pipes.

Should oak be selected for the general construction of some special stops, such as the Principal or Open Diapason, 8 ft., Gedeckt or Stopped Diapason, 8 ft., and the more choice kinds of Flutes, it would be well to remember that, owing to the strength and unyielding nature of the wood, much less thickness is necessary than for white pine or spruce under similar conditions of length, scale, wind-pressure, style of voicing, etc.

Beech (*Fagus sylvatica*).—This hard and close-grained wood has been occa-

sionally used by German builders for their cylindrical wood FLUTES. The FLAUTO TRAVERSO in the Organ in the Parish Church of Doncaster, made by Schulze, is of cylindrical beech pipes. Beech is frequently used for caps which require very careful manipulation and most accurate adjustment. It was used by Roosevelt for the compound caps of his harmonic CONCERT FLUTES. The chief imperfection of this wood is its liability to the attacks of insects which perforate it.

TEAK (*Tectona grandis*).—This grand wood is practically unknown to European and American organ builders, although it deserves an honored place in every workshop in which truly artistic work is carried on. This tree grows to a very large size in the forests of India, Burma, and Siam. The wood is of a yellowish-brown color, and is straight-grained and easily worked. When once seasoned it does not warp or crack. In all respects it is superior to oak in the construction of pipes; and should alone be employed in Organs destined for tropical climates. It is unrivalled in resisting the attacks of worms and ants; and it contains an aromatic resinous substance which preserves the iron screws which enter it. Teak can be obtained in sizes suitable for the largest pipes. We strongly recommend this useful wood to the attention of organ builders who do good work, for more purposes than those connected with pipe-making. It is specially suitable for case-work.

There are several other woods which may be pressed into the service of the organ pipe maker, but it is quite unnecessary to extend the list above given. We have mentioned all that are ever likely to be used in good work, and several that are little likely to be even contemplated by the purely tradesman organ builder of to-day.

CHAPTER XXXIV.

WOOD PIPES: AND THEIR MODES OF CONSTRUCTION.

THE construction of wood organ pipes is extremely simple, and calls for nothing beyond the ordinary tools used by the joiner. In large workshops, however, the usual labor-saving machinery and appliances are, of course, resorted to in the preparation of the wood for the subsequent manual processes. In the preceding Chapter all the woods suitable for pipe-making are more or less fully described and their properties noted.

As a convenient starting-point, we shall describe the construction of the pipes which form the ordinary GEDECKT or STOPPED DIAPASON, 8 FT. A pipe of this stop, so far as the general form of its tube or body and the shape and treatment of its mouth are concerned, may be accepted as the original and normal type of the quadrangular wood organ pipe. A pipe so formed may or may not have a stopper; for, with the exception of the proportions of length to transverse scale, there are no essential differences between the body of an *open* CLARABELLA pipe, as originally made, and that of an ordinary GEDECKT.

Before proceeding to construct a stop of wood pipes, it is necessary to procure a correct and well-approved scale, giving dimensions for the blocks, thicknesses of wood, heights of mouths, and sizes of caps; and also a rod with the lengths marked thereon, to which the pipes have to be cut when finished. It is sufficient for our present purpose to give a reduced representation of the scale of one octave, showing the manner in which all the chief finished dimensions are clearly marked for the guidance of the pipe maker. Fig. CCLV. may be considered the scale for the bass or lowest octave, the CC or lowest pipe of which will measure rather more than 4 feet in length, and the rest proportionate, the C pipe being a little over 2 feet in length from its block. In using this scale, measurements must be taken in all cases from the datum line—above it for all the important dimensions, and below it for the approved thicknesses of the pipe sides and caps. The greatest accuracy must

be observed in taking off all the important dimensions, for the regularity of tonal coloring in a stop depends to a large extent upon accuracy of workmanship. It is of little use having a correctly developed scale if it is not rigidly adhered to. The only dimensions which are practically matters of taste are the heights of the blocks and caps. These need not be graduated throughout, but may be made of the same height in each octave if preferred. Stops in which every detail is graduated, in accordance with the scale, are, however, the most pleasing in appearance.

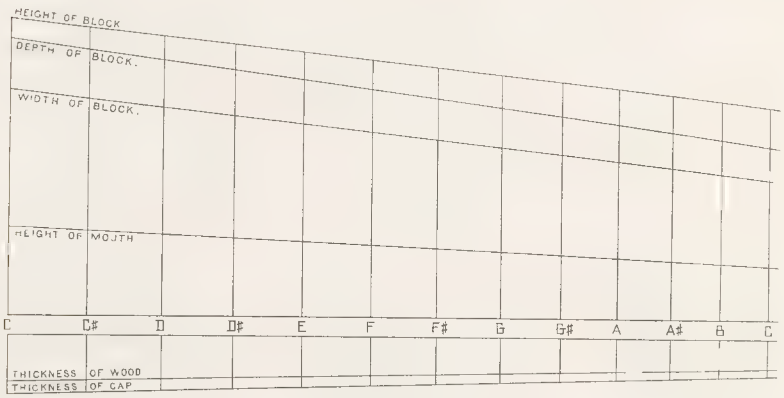


Fig. CCLV.

The blocks are the first portions of the pipes that have to be made. For blocks above 2 inches in depth the wood should be of two or more thicknesses of perfectly dry white pine, placed with the grain in different directions, and faced with some close-grained hardwood, all securely glued together. Blocks so built up stand better than those cut from single pieces of wood. The blocks for the small pipes may advantageously be made of some hardwood, such as cherry or close-grained mahogany. The wood should be glued up in lengths sufficient for six or eight blocks, and extra building-up pieces, of convenient thicknesses, for the tops of the pipes. In some cases it may be desirable to provide for slices, averaging 1½ inch thick, for the stoppers of the larger pipes. Commencing with the CC pipe, the wood should be dressed accurately to the depth and width of its block, having the hardwood on a narrow side, or what will be the face, or exposed side, of the block. The first block must then be carefully and squarely sawn off, in length about an inch more than the scale calls for. This extra length will be cut away when the body of the pipe is finished. A slice should then be sawn from the wood, about an inch thick, to serve as the building-up piece for the top of the pipe. Referring to the accompanying illustration, Fig. CCLVI., which shows a pipe in the different stages of construction, the block wood is represented at A, in Diagram 1, formed of two thicknesses of white pine with a facing of hardwood, as

already described. B is the block cut off, and C is the top building-up piece. When the first block has been thus secured, the piece A must be planed down to the next size on the scale, and the cutting-off process repeated, and so on until all the blocks and building-up pieces have been prepared. The top ends of the blocks

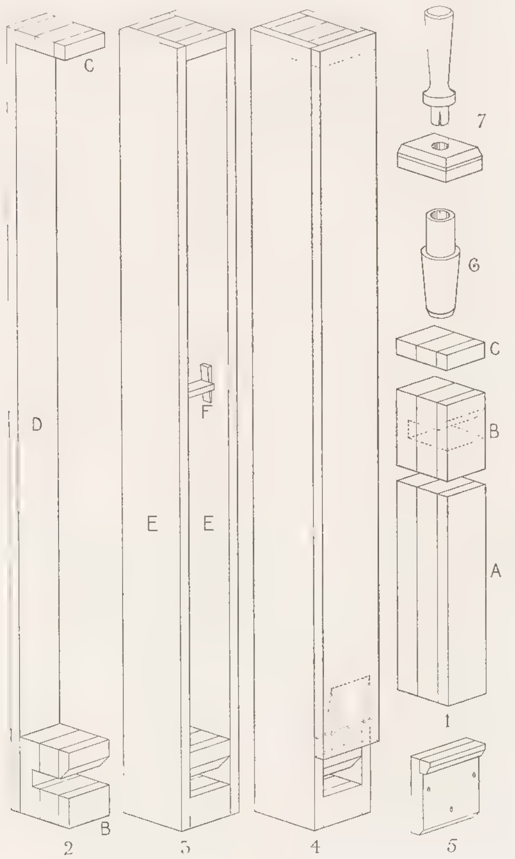


Fig. CCLVI.

must now be smoothed by a plane or sandpaper, the front edges, which form the under lips of the mouths, being left perfectly square and sharp. The next proceeding is the cutting of the throats in the blocks for the passage of the wind, as hereafter described. These should be cut with a fine saw and cleaned with a chisel. The dotted lines in the block B, in Diagram 1, indicate the direction and form of the cutting; while in the block B, in Diagram 2, the throat is shown

finished. The blocks at this stage are ready to be glued to the backs of the pipes.

Measurements taken from the two scales of widths and lengths, with due allowances for the thicknesses of wood and extra length of blocks and building-up pieces, enable the pipe maker to cut the pine boards for the backs and sides, and, subsequently, the hardwood fronts, for the pipe bodies. These should in all cases be sawn slightly in excess of the finished widths. When all are thus prepared, they should be dressed to nearly their final thicknesses; and one face of each piece must be planed true and smooth. The back pieces are now taken and one edge of each is shot perfectly straight, and square to the finished face.

We shall at this stage consider the formation of a single pipe, all the pipes of the stop being put together in precisely the same manner. A back is taken, and on one end of its finished face is firmly glued the block, care being taken to accurately adjust one side to the shot edge of the back: at the other end is glued the building-up piece, similarly adjusted. The relative positions of the three pieces, at this stage, are clearly indicated in Diagram 2; B being the finished block, C the building-up piece, and D the back of the pipe. When the glue is thoroughly dry, the undressed edge of the back is planed down until perfectly level with the side of the block and the corresponding side of the building-up piece, care being taken to avoid planing the edge of the back in any way hollow; while if it is very slightly cambered it will be rather an advantage than otherwise. Pipes, and especially large ones, speak more freely when they are a trifle larger, in cross section, in the middle than at the ends. The other edge of the back, which was originally shot, has just a shaving taken from it so as to secure its being perfectly true to the block and the building-up piece. In no case, however, must the block be touched, unless allowance has been made when its width was taken from the scale. Diagram 2, Fig. CCLVI., shows the pipe in the state ready to receive the side boards. These are now taken, and one edge of each is shot straight; they are then adjusted with their shot edges laid in line with the outside of the back board, and small holes are pierced through them close to each end, and into the waste length of the block and the building-up piece. These holes are for small wooden pegs to be used for fixing them in correct position in the necessarily hurried process of gluing up. When the glue is made as hot as possible and is brought to the proper consistency for use, the side boards are warmed at a stove or with a large flat-iron, laid side by side with their finished faces upward and their shot edges close together, and quickly covered with the hot glue at each end, where they will come in contact with the block and building-up piece, and for the necessary width along their faces at the shot edges. One side is quickly placed in position and pegged down, the pipe turned, and the other side immediately manipulated in the same manner. Before the glue has time to set, hand-screws are applied to both ends and at intervals along the back, firmly pressing the sides in contact with the block, back board, and building-up piece. In the case of a small pipe, thick pieces of wood, dressed true, should be placed on the sides of the pipe, and instead of hand-screws being used along the back, rough pieces of wood, with portions cut out so as to fit over the whole, should be placed at intervals and firmly wedged until the joints are perfectly closed.

The pipe having been tightly screwed up, and all the joints examined and found perfectly close, it is turned on its back, and with a brush, dipped in boiling water, the glue that may appear in the inside is washed away locally and spread, in the form of size, all over the inside surfaces of the back, sides, and block. Should the glue in the pipe not be sufficient to size the entire surfaces, some additional weak glue size may be added, for it is desirable that they should be well coated. The pipe is now laid aside to become thoroughly dry.

The hardwood intended for the front of the pipe is carefully dressed, on both sides, to the proper thickness; and one edge and end are shot perfectly straight and square. The inside face of the board is sized like the other inside surfaces, and is then ready for attachment to the pipe.

When the pipe is dry and the hand-screws are removed, it is laid on its back, and the front edges of the sides are planed down until they are level with the faces of the block and building-up piece. There is just a possibility that the sides may have bent inward slightly during the preceding process of gluing, screwing, and sizing, and it is necessary to rectify any inward tendency, and prevent its occurring while the front is being glued on. This is done by taking a small slice from the wood cut from the throat of the block, and wedging it between the sides of the pipe. The slice being the exact width of the block, the wedging has the effect of very slightly pressing the sides outward, a proceeding which is of advantage to the tone of the finished pipe. The condition of things at this stage is distinctly shown in Diagram 3, Fig. CCLVI., E E being the sides of the pipe, and F the expanding piece wedged in.

The pipe is now taken and the proper height of the mouth, measured from the upper edge of the block, is marked across the edges of the sides, and a pencil line is drawn across the upper part of the block, indicating the position of the top of the cap below the level of the lip or edge of the block. The front board is now laid on the pipe with its squared end accurately adjusted to the pencil line on the block, and the height of the mouth marked upon it. Then, with a square and a sharp knife, a deep cut is made across its inside face, at the mark, to ultimately form the upper lip of the mouth. The next step is the gluing of the front to the sides of the pipe. The edges of the sides are well warmed by passing a hot iron along them, and immediately covered with glue from the line on the block to the top of the pipe. The front, which has also been warmed, is quickly laid in position, pegged to the building-up piece, covered with a piece of straight board to serve as a caul, and pressed to the sides with hand-screws until the joints are perfectly closed.

When the glue has become dry, the pipe is released from the screws, and cleanly dressed on its sides and back until the desired thickness of wood is obtained. The pipe has now reached its complete state so far as its tube is concerned, and is ready to receive its mouth and be cut to its proper length. This stage is shown in Diagram 4, on which are indicated, by dotted lines, the form of the mouth, and the portion to be cut from the top of the pipe. The block end is shown cut to its finished size. The vertical lines at the sides of the mouth, and the horizontal line indicating the height of the mouth externally, are now drawn on the front, and the mouth is carefully cut out until its slope meets the knife-cut

previously made on the inside. The slope of the mouth is now accurately formed so as to leave the upper lip of the requisite thickness. When this very simple process is completed, the top and bottom of the pipe are sawn at the lines already marked, and the bottom is dressed square; then the small wedged piece inside is knocked away, and the body of the pipe is finished, ready for the reception of its cap, foot, and stopper. The exterior of the cap is shown in Diagram 5. It is formed of hardwood and furnished with a projecting piece, commonly called a "beard," an adjunct not always necessary, as subsequently explained. The cap is hollowed on the inner side to form the windway of the mouth. We treat of this matter fully elsewhere. The foot, a turned piece of wood through which a hole is bored, is shown in Diagram 6: this is inserted in a hole bored in the bottom of the block into the throat, and through it the wind from the wind-chest enters the pipe. The stopper, with its handle detached, is shown in Diagram 7. This may be made of two layers of white pine glued together with their grains running at right angles, or from a slice cut from the wood prepared for the block, such as appears at C in Diagram 1. In either case the stopper is dressed so much smaller than the inside of the pipe as to admit of a covering of thick and soft leather, or of felt and leather combined, for the purpose of making its edges air-tight against the four walls of the pipe, while allowing it to be moved up and down in tuning. The upper edges of the stopper are splayed, as shown, and its lower edges and its corners are very slightly rounded to prevent their cutting the leather. In the accompanying illustration, Fig. CCLVII., the pipe, constructed and finished as above described, is clearly represented. It is an ordinary English Stopped Diapason CC pipe of 4 feet speaking length, and, accordingly, of 8 feet tone.

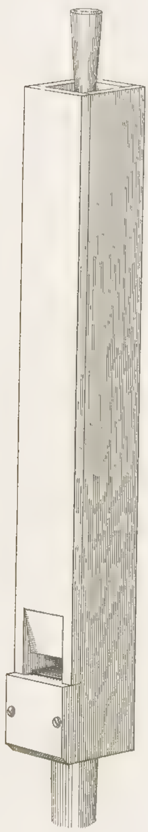


Fig. CCLVII.

In the preceding description one method of building up the body of a wood pipe has been given, but there is another method preferred by many pipe makers. We have constructed pipes in both ways and have found them both satisfactory. The accompanying Transverse Sections of pipe bodies, A and B, Fig. CCLVIII., show the methods. At A is shown the method already described, and illustrated in Fig. CCLVI., in which the back of the pipe is the portion to which the block and building-up piece are first attached; while at B it will be seen, by the jointing, that the block has first to be glued to one side and then the other, the back being applied subsequently in the same manner as the front. The only true advantage that can be claimed for the latter method is that it prevents any possibility of the back bending either inward or outward. It is just possible

that some hands may find it the easier mode of construction. For pipes such as those of the Doppelflöte and Philomela, with two mouths, the latter method is imperative, for such pipes have two fronts and, accordingly, no back.

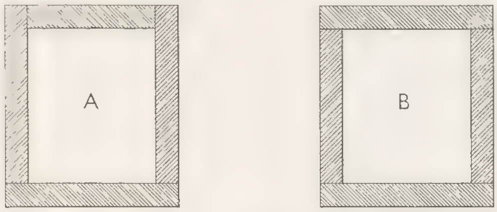


Fig. CCLVIII.

Probably enough has been said, up to this point, to dispose the student of the art of organ-building to take some lively interest in matters connected with the formation of wooden pipe-work. We have hastily laid before him the mode of putting together and finishing the several portions of an ordinary quadrangular pipe—we use the word quadrangular because it is not the only shape adopted for pipes of wood—which, with some minor points of difference, is the mode practically followed in the construction of all the different families of such pipes. He will, accordingly, be prepared to follow us in the consideration of those minor points of difference, chiefly connected with the sound-producing portions, which exert an all-important influence on the tones of the pipes.

In the first place, it is desirable to note the three types of mouths upon which every form of mouth met with in wood pipes is based. These are shown, in section, in Fig. CCLIX. At A is represented what, for the sake of distinction, may be called the *English mouth*, from the fact that it was universally used by the old English organ builders, although we cannot say exclusively by them. It will be observed that the upper lip is formed by cutting a slope on the outside of the pipe, while the under lip is formed by the edge of the block, and a hollowed cap depressed slightly below the level of the same. The wind-way is made in the inner, thin edge of the hollowed cap, as clearly indicated in the Section. This is the form of mouth in the Gedeckt or Stopped Diapason pipe illustrated in Fig. CCLVII. Under ordinary conditions it produces a soft and singing quality of tone, so much affected by the old English builders.

At B is shown what is commonly known as the *German mouth*, because it has always been a favorite form with the German masters. The upper lip is formed similarly to the preceding, but the lower lip is differently treated. In this type of mouth the cap is flat on the inside and placed level with the upper edge of the block, the block being sloped from its upper edge downward into the throat, and having the wind-way cut in it, and not in the cap as in the preceding type. This treatment, under normal conditions, produces a powerful and somewhat incisive quality of tone, dear to the lovers of loud-voiced stops.

At C is represented what is called the *inverted mouth*, because the slope forming its upper lip is cut on the inside of the pipe, and its lower lip is formed by the perforation of the front, and not in any way by the block, which latter in this type is almost invariably sunk below the level of the lower lip. The cap is hollowed, and depressed below the lip, having the wind-way cut from it, as in the English mouth. This form of mouth is adopted for the imitative and clear-toned FLUTE stops, and certain others of crisp intonation. The Longitudinal Sections of pipes, drawn in perspective, Fig. CCLX., on the opposite page, show in a very clear manner, the formation of the German and the inverted mouths, and the respective treatments of their wind-ways.

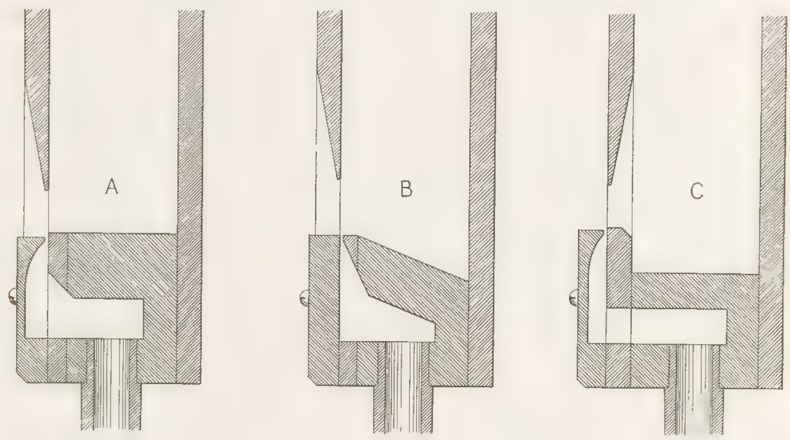


FIG. CCLIX.

Such, then, are the three types of formation which are followed in the construction of the lips and wind-ways of all wood pipes. Outside these, however, there are many modifications and additions which experiment and experience have introduced for the purpose of producing varieties of tonal coloring. So much has been done in this direction, that from quadrangular pipes of wood have been produced pure organ-tones of considerable volume and richness; flute-tones of both normal and highly imitative character; string-tones so closely resembling those of the orchestral Violoncello and Double Bass as to be absolutely deceptive under certain conditions; and tones resembling those of reeds. It is, accordingly, our purpose in the following pages of this Chapter, to lay before the reader particulars and illustrations of the several characteristic treatments which have been invented and introduced by artists in pipe-voicing with the aim of furnishing such varieties and qualities of tone as are essential in so large and comprehensive an instrument as a Concert-room Organ. We may remark that in the preparation of the illustra-

tions—all of which have been drawn by our own hands, and reproduced by photo-engraving—we have in all possible cases worked from existing pipes, and have endeavored to be accurate in all the essential features and proportions of parts. The task has been a laborious but a very interesting one; for in no work, nor, indeed, in all the works hitherto published on the Organ put together has so extensive a series of illustrations appeared relating to the formation of wood pipes.

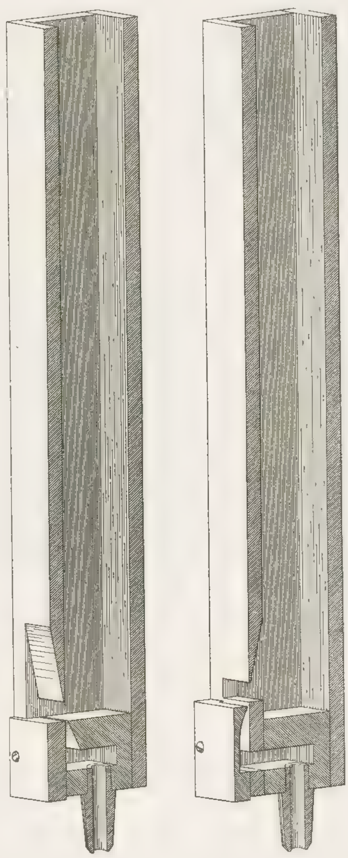


Fig. CCLX.

WOOD PIPES OF ORGAN-TONE.

There are only two or three varieties of wood pipes which can be recognized as producing pure organ-tone, that is, tone which is of the same character as that yielded by the metal stop of large scale, commonly known as the Open Diapason. That such a tonal character can be produced from properly-formed and -voiced quadrangular wood pipes has been proved, beyond dispute, by the great Schulze Principals or Open Diapasons. The most important stops of this class are the Principal, 16 ft., and the Double Principal, 32 ft.* properly belonging to the Pedal Organ. The stops are formed of quadrangular pipes, the CCC and the CCCC pipes having, respectively, the "theoretical speaking lengths" of 16 feet and 32 feet. Their practical lengths vary in accordance with their scales and musical pitches. In the illustration, Fig. CCLXI., on page 442, is represented the sound-producing portion of a pipe of a Principal or Open Diapason, 16 ft., as commonly constructed. This is shown in its complete form, in Longitudinal and Transverse Sections, and dissected. The mouth is of the English form, but with two additional parts not hitherto mentioned; namely, the projecting pieces at the sides of the mouth, designated the ears. These are applied to such large pipes of this class, to confine and steady the wind stream, preventing it from spreading laterally. Ears, however, are not invariably applied of

* Stops of the same names and lengths are also made of metal.

so great a projection as those indicated. Referring to the Longitudinal Section, Diagram 1, it will be seen that, instead of a solid block as previously described for the STOPPED DIAPASON, 8 FT., two horizontal boards are used, placed at a convenient distance apart, and let into grooves cut in the back and sides of the pipe. The space between the boards forms the throat. The grain of both the boards must run from side to side of the pipe; and the upper board, which may be called the languid, should be edged with a piece of maple, or some other hardwood, to form a satisfactory under lip. In such large pipes, the upper lip should be of hardwood with its grain running across the mouth. The manner in which this is attached to the soft wood front, by grooving and tonguing, is clearly shown. The Perspective View, Diagram 2, represents the lower portion of the pipe complete and with all its parts in place. Diagram 3 shows, separately, all the portions which

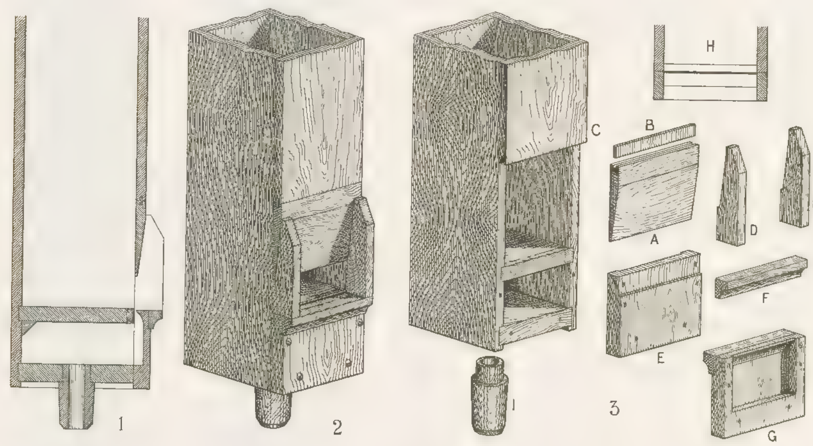


FIG. CCLXI.

form the mouth. A is the hardwood upper lip, sloped to produce the proper thickness at the mouth; B is the tongue, also of hardwood, required to join the upper lip to the end of the front board, C; D D are the ears, shaped to fit the upper lip, etc.; E is the cap, as seen from the outside; and F is the beard, which is securely glued and screwed to the check in the cap. At G is shown the cap, as seen from the inside, hollowed, and with its wind-way cut; and at H is given a Transverse Section through the mouth, looking toward the languid and cap, the wind-way being indicated by the thick black line. The pipe-foot is shown at I.

Pipes of this class are also made with mouths of the German form, that is, with their languids and caps placed at the same level, and their wind-ways cut from the face of the languids. In some cases, with the view of improving the speech, the wind-way is cut a little short, at both sides, of the width of the mouth.

A pipe voiced in this manner can easily have its wind-way extended to the full width if found desirable. It is probable that this shortening of the wind-way steadies the wind-sheet by permitting it to spread slightly before it reaches the upper lip. This is likely, because pipes with full wind-ways are often improved in speech by having small wedges stuck in them. PRINCIPAL pipes with the German mouth yield a clearer and stronger tone than those with the English mouth, all other conditions being equally favorable.

With respect to the most desirable scales for the Pedal Organ PRINCIPALS, opinions have differed widely in the past through the different lights in which the office of the Pedal Organ has been viewed by English and Continental builders. Clear and settled ideas on the subject do not seem to obtain in the somewhat hazy organ-building mind of the present day: accordingly, a few emphatic words respecting it may be of some service.

The Pedal Organ is not an independent and self-contained department, but one which is entirely dependent on, and dictated by, the contents of the manual divisions of the instrument. All the Pedal Organ stops must be viewed and treated as furnishing true basses for the more important stops of the manual Organs; and their scales must, accordingly, be derived from, or dictated by, the scales of those manual stops. Let this important and surely self-evident fact be recognized, and all becomes a simple matter, no longer subject to ignorant caprice, but governed by reasonable laws. The old, and the greater number of the modern, English organ builders, in their vain attempts to make a single OPEN DIAPASON serve as the bass for twenty or more manual stops, were compelled to use inordinate scales. To this simple fact we owe the construction of 16 ft. pipes with such excessive, and to our mind absurd, internal dimensions as 22 inches in width and 24 inches in depth; or, more frequently, 18 inches in width and 20 inches in depth. Stops formed on such immense scales were unmanageable monsters, tolerable only with the full Organ, and absolutely ridiculous, from an artistic point of view, with softer combinations: and the great floor-space they occupied usually led to the undesirable cramping of every other part of the instrument. The German and other Continental builders, in their appreciation of the true nature and office of the Pedal Organ, never, so far as we have been able to learn, used scales even approaching those above mentioned. The largest scale known to us in German Organs is 12 inches in width and 14 inches in depth, while the generality of Pedal PRINCIPALS, 16 FT., rarely exceed 9 inches in width by 11 inches in depth. Yet from pipes of these scales tones of great purity and power are obtained. High mouths and a copious supply of wind are important factors in the production of such tones. Three scales for the CCC pipe of the PRINCIPAL, 16 FT., may be recommended for general use; namely, 8 inches by 10 inches; 9 inches by 11 inches; and 10 inches by 12 inches. Fractions of an inch may be added to either of the widths or depths given, according to the fancy of the voicer; but little will be gained by exceeding the largest scale either in width or depth. The late Mr. W. T. Best, of Liverpool, was strongly in favor of the scale of 10 inches by 12 inches; and he was the best judge of organ-tone in his day. We have proved the scale of 8 inches by 10 inches to be perfectly suitable for a Chamber Organ on a

low pressure of wind. It would also be quite sufficient for a softly-voiced Church Organ, on wind of 3 inches or 3½ inches. It must be borne in mind that this stop has to carry down, with a proper tonal balance, the foundation metal PRINCIPAL, 8 FT., of the manual department of the Organ. As in organ pipes there is always a tendency toward weakness of tone as they ascend in pitch, it is advisable to keep the scale as full as possible (consistent with good tone) throughout the compass. We accordingly advise the adoption of the ratio 1 : 2·519, which halves the size of the CCC pipe on FF♯, or the eighteenth pipe.

The height of the mouth in all the suggested scales may vary from ¼ to ½ the width, according to the pressure of wind, and the strength and quality of tone desired. A height equal to ⅓ the width of the mouth is, under general conditions, productive of a good and pure tone, practically free from harmonic upper partials. Care must be taken to provide, by large pipe-feet, an ample supply of wind: this is an essential condition in the production of a satisfactory tone. The foot of the CCC pipe should have a bore of not less than 2 inches diameter.

In the construction of the PRINCIPAL, 16 FT., wood of considerable thickness must be used; for although the tone is not produced by the vibrations of the walls of a pipe, it may be seriously injured by them, especially by the undue vibrations of the sides. Observation leads us to believe that the maximum vibration is always at the sides of a labial pipe, and that there is comparatively little at the front and back.* Should this be found to be the case generally, it would point to the desirability of thicker wood being used for the sides than for the back and front of a pipe of large size. If white pine is used, the CCC pipe should be built of clear stock, which will give a thickness of 1⅝ inches when dressed. Thinner wood than this is frequently employed, but at a great risk of failure in the matter of tone. It must be remembered that large-scale pipes require thicker wood than small-scale ones. For a copiously-winded 16 ft. pipe, measuring 10 inches by 12 inches, we recommend sides of 1⅝ inches, finished thickness, and front and back of 1½ inches. All the other pipes to be properly graduated to the F, or top pipe, which should have sides of ¾ inch and front and back of ⅝ inch, finished thickness. Nothing save unwise economy can dictate the use of thin wood for large pipes.

As the form and construction of the DOUBLE PRINCIPAL, 32 FT., differ in no essentials from the form and construction of the Pedal PRINCIPAL, 16 FT., it is unnecessary to go further into those matters than to point out the advisability of building pipes of so large a size in the most substantial manner that can be devised. The bodies of the pipes of the 32 ft. octave should be put together with grooved and tongued joints, as indicated in Fig. CCLXII. Indeed, it is desir-

* This phenomenon was first brought to our notice by the peculiar behavior of a bass pipe of a metal PRINCIPAL, 8 FT., which, in the course of being regulated in its place in a "tower," could not be made steady in tone. Every known expedient was tried at its mouth without permanent effect. We say permanent, because while the pipe was held, by the two hands, on the voicing block, its speech was perfectly steady, but immediately it was returned to its proper place, its tone became wavy and unsteady. After a great deal of testing, we discovered that the tone became true only while it was held by both hands placed firmly at its sides, in line with the direction of the wind-way. This naturally led to the examination of the form of the body of the pipe, which was found to be oval, or slightly flattened at its sides. This caused a weakness at the places of maximum vibration, which the deficiency in the thickness of the metal used materially aided. When restored to a circular form all unsteadiness vanished.

able that all pipes of the 16 ft. octave, in all Pedal Organ stops, should be constructed in this secure manner. It would seem to be the method that was adopted for all wood pipes in the time when Dom Bedos wrote—about the middle of the eighteenth century—for it is the only method illustrated in his great work. When of a reasonable scale, the CCCC pipe should have sides of 2½ inches, finished thickness, and front and back of 2¼ inches. Should there be any tendency to unsteadiness of speech, transverse bands of wood, about 6 inches wide by 1 inch thick, may be glued and screwed to the sides of the pipe where the tremor in the same is felt to be greatest.

The most appropriate scales for the Double Principal, 32 ft., are not proportionately so large as those recommended for the Pedal Principal, 16 ft. This may be explained by the facts that the unison or fundamental pitch of the Pedal

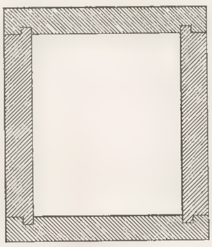


Fig. CCLXII.

Organ is 16 ft., and that it is undesirable to have the sub-octave pitch as pronounced as the unison. When the Pedal department is strong in stops of 16 ft. pitch, greater liberty can be exercised respecting the scale, within reasonable limits, for the Double Principal.

The largest scale that need be used under all ordinary circumstances, gives the CCCC pipe the size of 14 inches by 17 inches; while the scale of 12 inches by about 15 inches, as used by Schulze in his Organs in the Cathedral of Bremen, and St. Mary's Church, at Wismar, may, on his authority, be accepted as one perfectly suitable for a large Church Organ. It is to be noted, however, that he favored larger scales under certain conditions. For instance, the 32 ft. stop in his fine Organ in the Church of St. Bartholomew, at Armley, Yorkshire, has the original CCCC pipe measuring 14¼ inches in width by 18¼ inches in depth. Owing, as we understand, to a mistake on the part of an English organ builder during the re-erection of the Organ, this pipe was cut too short, and now serves as CCCC♯. The present CCCC is of covered wood. The treatment of the mouths of the original pipes is interesting. The mouth of the largest of these is represented, in section and front view, in Fig. CCLXIII. This treatment imparts a crisp and prompt intonation, with a slight leaning toward string-tone, which may be considered an advantage in so grave a voice. The practice of adding the harmonic-bridge to large wood pipes belonging to Pedal stops of 32 ft. pitch has been suc-

cessfully followed by other builders. The original CCC pipe (16 ft.) in Schulze's stop measures 9 inches in width by 11 3/8 inches in depth internally.

The most suitable minimum scale may be accepted as 11 inches in width by 13½ inches in depth for the CCCC pipe, halving on the eighteenth pipe. It has been used, approximately, by Walcker and other great German builders. Larger scales than the minimum above given have, as might be expected, been adopted by English builders; and inordinate scales have not been without their advocates among those who ranked musical sounds from such grave pipes as good in proportion to their power of shaking windows and doors. We are told by Dr. Hopkins that the CCCC pipe of the DOUBLE OPEN DIAPASON inserted by Hill, in 1848, in the Organ of Westminster Abbey, measured 19 inches

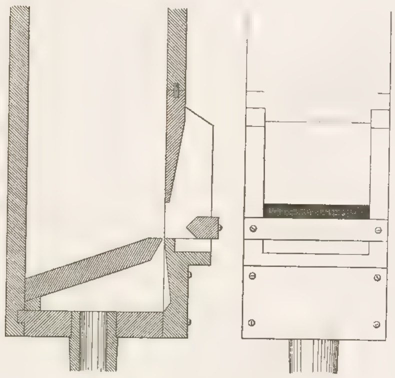


FIG. CCLXIII.

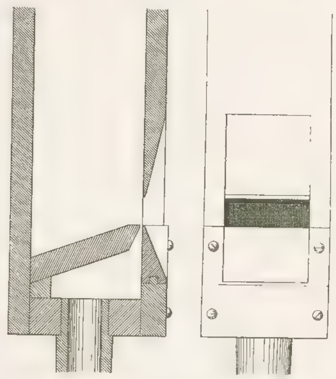


FIG. CCLXIV.

by 22 inches: and, as an example of an inordinate scale, that the same builder's 32 ft. wood stop in the Concert Organ in Birmingham Town Hall, has the CCCC pipe measuring 12 ft. in circumference, with an internal capacity of 224 cubic feet. We have been told by one of the actors in the scene, that before this monster pipe was put in its place, twenty men sat inside it, and drank to its long life and good behavior in foaming English ale. Such a scale as this, or, indeed, anything approaching it, is as undesirable as it is unnecessary: it simply marks an epoch of uncertainty and misconception in English organ-building.

PRINCIPAL or OPEN DIAPASON, 8 FT.—Although the PRINCIPAL, 8 FT., of wood, as a manual stop, has very seldom been carried above the bass octave by German organ builders, and has, so far as we can learn, never been introduced by English builders, there are strong reasons in favor of its being added to the list of stops available for modern use. That it can be made of a beautiful quality of tone has been satisfactorily shown by Schulze—that consummate artist in wood-pipe voicing. In his Organ in Armley Church, the bass octave of the "MAJOR PRIN-

CIPAL" in the Great Organ—a truly grand stop of pure organ-tone—is carried down in wood pipes in so perfect a manner that the keenest ear almost fails to detect the transition from metal to wood. The accompanying illustration, Fig. CCLXIV., shows the peculiar construction of the mouths of these bass pipes. It will be observed that the external lines of the upper lip and the splayed cap resemble those of an ordinary metal-pipe mouth. The chief feature here is the recessed and splayed cap, which is almost brought to a sharp edge at the lower lip. The upper lip is cut sharp, as shown. In the matter of scale, the most important dimensions are those of the BB pipe which follows, downward, the metal tenor C pipe. The metal C pipe is 3 3/8 inches in diameter, with a mouth 3 inches wide and 3/4 inch high, and with the wind-hole in the foot 9/16 inch in diameter. The BB wood pipe measures 2 13/16 inches in width by 3 3/4 inches in depth, with a mouth 7/8 inch high. All is of hard pine with the exception of the upper half of the cap, which is of oak. The languid slopes downward toward the back of the pipe. All the details are accurately shown in the illustration. The "MINOR PRINCIPAL," 8 FT., in the Choir Organ, has its bass octave of wood; the "SUB-PRINCIPAL," 16 FT., has its bass and tenor octaves of wood; and the "GEIGENPRINCIPAL," 8 FT., in the Swell Organ, has its bass octave in wood pipes. All are specimens of masterly voicing. The last-named stop does not yield pure organ-tone, notwithstanding that it usually appears, in a division of the Organ, as a substitute for, or in place of, the OPEN DIAPASON. Its German and English names—GEIGENPRINCIPAL and VIOLIN DIAPASON—indicate its leaning toward string-tone, caused by its giving some prominence to the second upper partial tone along with the prime tone.

WOOD PIPES OF FLUTE-TONE.

The greater number of wood stops introduced in the different divisions of the Organ are those which yield flute-tone either unimitative or imitative: and the pipes which compose such stops present a great variety of scales and treatments; are of several essentially different forms; and are either open, covered, or half-covered. A displayed list of merely the names of flute-toned wood stops, which have been introduced by organ builders at different times with the view (often a mistaken one) of expressing or marking some peculiarities either in the forms of their pipes, or in their tonal colorings, would go far toward filling a page of this treatise. The principal ones are given in the Chapter on the Names of Organ Stops, accompanied by a brief digest of the peculiarities of the stops. Here we shall confine our remarks to such flute-toned pipes as represent special types, and which present marked structural features, devised for the purpose of producing different intonations or qualities of voice.

Flute-toned stops, both of wood and metal, may be grouped into two classes: First, those which yield organ flute-tone; and, secondly, those which yield orchestral flute-tone. The former are unimitative, and may be called normal flute-toned stops; while the latter yield tones closely resembling those of the orchestral Flute and Piccolo, and may, accordingly, be designated imitative flute-toned stops. The term normal is here used to convey the idea that the tone is produced under the

ordinary conditions of organ pipes, and may vary infinitely according to scale, voicing, wind-pressure, etc. : while in the case of the imitative stops, everything is made subservient to the production of an exact quality of tone—that of the orchestral Flutes—and such extraordinary forms and treatments are resorted to as may be found necessary to attain the end in view. With this explanation, it will be understood what is meant when we speak of a FLUTE pipe having a normal or an imitative tone.

CLARABELLA.—The first stop of normal flute-tone that may be considered here is the modern one known as the CLARABELLA : a stop of 8 ft. pitch belonging to the manual department of the Organ. In its most pleasing and useful form it has a voice of a full and round character, inclining toward pure organ-tone rather than toward flute-tone. Some voicers give it a pronounced flute-tone, resembling that which is characteristic of the HOHLFLÖTE ; but in this case the chief charm and musical value of the CLARABELLA are sacrificed. The CLARABELLA pipe is quadrangular and open. It has the English mouth, the height of which should be about one-quarter of its width, without applied ears or beard ; and the block is level on its upper surface. The exact treatment is shown in the Longitudinal Section A, Fig. CCLX. The scale may be varied according to the tonal character desired. As both volume and character of tone depend upon the proportion the mouth bears to the internal transverse area of the pipe, it can readily be understood how easy it is for the pipe maker to vary the intonation by altering his scale. For a true CLARABELLA the proportion of width of mouth to depth of pipe may be as 3 to 4, when a comparatively light tone is required : or as 3 to 3½, when a full tone is necessary. It is undesirable to approach nearer to the square than the latter proportion.

The CLARABELLA is seldom carried down below tenor C, being either completed by twelve covered pipes, or grooved into the bass of some suitable stop, such as the STOPPED DIAPASON. Both these expedients are to be condemned, for the bass octave of the CLARABELLA, when correctly made and artistically voiced, is both beautiful in tone and valuable in combination. It is the rare mixing property of the CLARABELLA that gives it its great charm ; and this should never be interfered with. The upper octave of this stop has been made of metal ; but this is neither advisable nor necessary. There is no difficulty in making and voicing even the smallest pipes required ; and when carefully treated, their tones are much more pleasing than those yielded by metal pipes.

The best woods for the CLARABELLA are white pine and spruce of the proper quality. The bass pipes should have hardwood upper lips ; and both their caps and the facings of their blocks should be of mahogany, black walnut, or maple. The pipes from C to b^1 should have hardwood fronts, although very fine pipes have been made of white pine throughout. Nothing can be better for the backs and sides of the pipes from c^2 to c^4 than piano sound-board spruce. These should have pear-tree or maple fronts. In all cases the caps and the facings of the blocks should be of hardwood. We have made a good-toned CLARABELLA (tenor C to g^3) of straight-grained white pine throughout, with, of course, the exception of the caps and facings of the blocks (which are of Spanish mahogany), but we do not

recommend the practice. As the CLARABELLA, when made with the proper height of mouth, requires little wind, an inch bore is ample for the CC pipe, and the rest in proportion, allowance being made for plugging.

STOPPED DIAPASON.—The name of this time-honored stop is certainly misleading, for it does not belong to the DIAPASON family. Its characteristic voice places it in the flute-work, although, like the CLARABELLA, its fluty character is not, in genuine examples, very pronounced. As the form and construction of its pipes have already been described and illustrated, it is unnecessary to add much here. While its tone of necessity differs from that of an open stop like the preceding, its form differs from that of the CLARABELLA, generally considered, only inasmuch as its pipes are about half the speaking length and are stopped or covered. If there is any harmonic upper partial tone heard in the voice of the CLARABELLA pipe, it will be the first, or the octave of the prime tone; while in the STOPPED DIAPASON pipe, the upper partial heard is the second, or twelfth, of the prime tone —the first "over-tone" of a stopped pipe. Herein lies the distinctive difference between the voices of the CLARABELLA (open stop) and the STOPPED DIAPASON (covered stop)—a difference of coloring only in the normal flute-tone yielded by both stops. STOPPED DIAPASON pipes furnish the best bass octave for a tenor C CLARABELLA. They can be scaled and voiced so as to make the break almost imperceptible. The STOPPED DIAPASON should be in all cases carried throughout the manual compass in wood pipes. It should invariably be introduced in a complete form.

MELODIA.—This stop is of the CLARABELLA class, but owing to difference of scale and form of mouth it yields a tone of more fluty character. The scale varies in different examples; but that which gives the CC pipe a width of 3½ inches and a depth of 4¼ inches, halving on the eighteenth pipe (F♯), is probably the most satisfactory. The mouth is inverted, and cut up about one-third its width. The pipes are best made of white pine or spruce, with fronts of mahogany or maple, with caps to correspond; and as they do not require a greater provision for windage than the CLARABELLA, the bore in the foot of the CC pipe need not exceed 1 inch in diameter.

Organ builders, in their desire to save money, very commonly make the bass octave of the MELODIA of LIEBLICHGEDECKT pipes, but this practice, like too many others indulged in by them, is contrary to the canons of artistic organ-building, a very important one of which may read thus: *Each stop in the Organ must be carried throughout the compass of the instrument in pipes of its own class or tonality: and the bass of one stop should never be made to serve for the bass of other stops.* Those interested in the construction or acquisition of an Organ should insist on this canon being strictly observed. More of the grandeur and true beauty of the tonal structure of the Organ depends upon its observance than is commonly realized even by those who prepare specifications for Organs. The MELODIA, 8 FT., in its complete and most perfect form, is a beautiful-toned stop, valuable alike in combination with other stops of all classes and in solo effects. The MELODIA pipe is represented in Fig. CCLXV. Like all the smaller-sized open wood flute-toned pipes, it is tuned by a metal shade at top.

The DOUBLE MELODIA, 16 FT., should be made of precisely the same form as the MELODIA; but the pipes of the lowest octave may only have their mouths of hardwood, with the rest of their fronts of white pine or red-wood.

WALDFLÖTE.—This normal flute-toned stop is commonly made of 4 ft. pitch. From its general resemblance, in form and construction, to the MELODIA, it may be looked upon as the true OCTAVE of that stop. Its pipes are made of somewhat larger scale, and voiced to yield a full fluty tone, much more pronounced than that of either the CLARABELLA or MELODIA. The mouths of the pipes should be finished at about one-third the width in height, and have straight upper lips; but the proportions may vary according to the wind-pressure, and the quantity and quality of the tone required. We have made a most satisfactory and sweet-toned WALDFLÖTE, voiced on wind of 2 3/8 inches pressure, the pipes of which are of clear white pine, those from CC to b^1 being fronted with close-grained Spanish mahogany, and from c^2 to the top with pencil cedar. The mouths are inverted, and their upper lips are cut thin but not sharp. The blocks are depressed below the lower lip, the distance being equal to one-third the width of the mouth.


FIG. CCLXV.

The English stop is almost invariably made of wood throughout; but the German WALDFLÖTE is generally made entirely or partly of metal. We greatly prefer the tone of the former to that of the latter, it being more refined and of better mixing quality. As we have before remarked, it is desirable to retain all the characteristic wood stops in use, to counteract the modern inclination toward the exclusive adoption of metal pipes. As, to all appearance, the WALDFLÖTE pipe is identical with that of the MELODIA, it is unnecessary to give an illustration of it.

CLEAR FLUTE or HELLFLÖTE.—This is another open wood stop of 4 ft. pitch, yielding normal flute-tone approaching an imitative quality, being clearer and brighter in tone than any of the preceding stops. The pipes are made with inverted mouths; and have splayed and beveled fronts below their under lips, and flat and flush caps. The form of mouth is a combination of the inverted and the German treatments. In scale the CLEAR FLUTE should be smaller than the WALDFLÖTE and MELODIA. The largest (4 ft.) pipe may measure 2 1/8 inches in width by 2 1/2 inches in depth; and the height of its mouth may range between one-third and two-fifths its width. The pipes should be constructed of the same materials as already mentioned for the pipes of the WALDFLÖTE.

HOHLFLÖTE.—This is a powerful, but rather dull-voiced, stop of normal flute-tone, differing both in the shapes and proportions of its pipes from all the preceding examples. In the wooden varieties of the stop two leading forms obtain—the quadrangular and the triangular. In the most characteristic treatment of the quadrangular form the open pipes have their mouths cut in their wide sides,

as in the Hohlflöte in the Organ in the Town Hall, Northampton, constructed by Schulze. In the accompanying illustration, Fig. CCLXVI., the mouth portion of a pipe of this treatment is shown in front view and section. The mouth is of the German class, cut up equal to one-half its width, and having its side-pieces and the upper part of the cap sloped toward the opening.

In Fig. CCLXVII. are shown, in front view and section, the mouth portion of an open pipe from the Hohlflöte, in the back Great Organ of the Concert Organ in the Public Halls, Glasgow, constructed by Messrs. Lewis & Company. The C pipe of this fine stop measures $2\frac{1}{8}$ inches in width by $2\frac{1}{16}$ inches in depth. The mouth, cut in the narrow way of the pipe, is nearly square, being $1\frac{7}{8}$ inches high.

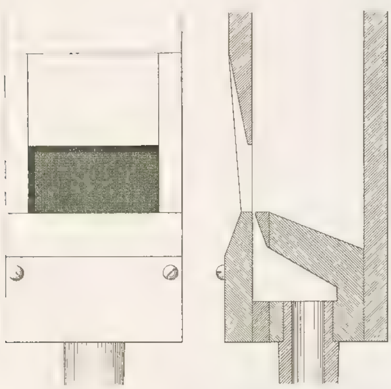


Fig. CCLXVI.

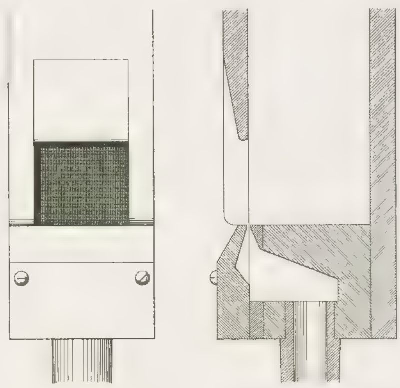


Fig. CCLXVII.

All these proportions are correctly given in the illustration. As in the preceding example, the cap is sloped toward the lower lip, and is slightly hollowed on the inside, as shown. The upper part of the pipe has a slot, 5 inches long, cut 2 inches from the top. The bass octave is in covered pipes, as is usual in Hohlflöte stops.

Schulze has used triangular open pipes for the Hohlflöte stops in his Organs in the Parish Church of Doncaster, St. Bartholomew's Church, Armley, and St. Peter's Church, Hindley. The illustrations given in Fig. CCLXVIII. are a Transverse Section, a Longitudinal Section, and a Front View of the mouth of the middle c^1 pipe of the Hohlflöte, in the Great division of the Organ in the Church of St. Peter, Hindley. It measures $1\frac{5}{8}$ inches in width at the mouth by $2\frac{1}{8}$ inches in depth, and its mouth is $\frac{7}{8}$ inch in height and arched, as shown. The adoption of the triangular form is for the purpose of obtaining a mouth large in proportion to the transverse area of the pipe: and it is with the same view that Schulze placed the mouth on the wide side of his pipes in his Northampton Organ, as above mentioned. The upper lip of the Hohlflöte is usually finished thick and slightly rounded, favoring the production of its somewhat dull and hol-

low tone. The pipes should be made of thick wood, fronted with hardwood, and have large feet for the copious supply of wind. We may remark that there is very little gained by the adoption of triangular pipes, notwithstanding the good opinion the great artist in pipe-voicing apparently had of them. It is generally understood, but upon what authority we are unable to say, that Schulze used them for the first time in the Organ in the Parish Church of Doncaster, which was built in the year 1862. However this may be, it is certain that the form of pipe was unknown in English organs prior to its appearance in the Doncaster instrument. Triangular pipes have also been used for another stop, as is shown further on; but they have never taken any hold in the utilitarian minds of our modern organ builders. It is quite certain that the additional labor and care attending the construction of triangular pipes will always militate against their use for a stop that can be satisfactorily made of quadrangular form.

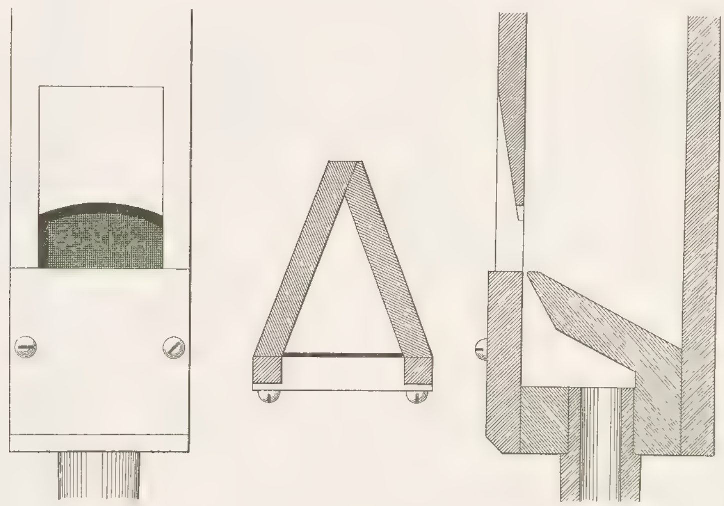


Fig. CCLXVIII.

German organ builders, in their desire to obtain as wide a mouth as possible in a square pipe, have introduced an oblique mouth in some of their Hohlflötes; by this expedient gaining a slight excess of width over that furnished by a horizontal mouth. The tone of the pipes is in no way interfered with, beyond a slight increase in power, by this treatment, as the wind-sheet, rising vertically, has the same distance to travel at every point to reach the upper lip. In the illustration, Fig. CCLXIX., are shown a Front View and Section of a square Hohlflöte pipe, having the oblique German mouth and inclined block.

The Hohlflöte appears to invariably have its bass octave of stopped pipes, special, or borrowed from some other stop, as in the Armley Organ, where it is

grooved into the LIEBLICHGEDECKT. This practice of borrowing should never be indulged in in good Organs. In the same Organ the stop has its top octave of metal pipes, and may, accordingly, be called a "made-up" stop.

LIEBLICHGEDECKT.—Of all the varieties of covered stops the true LIEBLICHGEDECKTS are the most valuable and beautiful. They form quite a large family, appearing in 16 ft., 8 ft., 4 ft., and 2 ft. pitch, all of which are properly introduced in the manual divisions of the Organ. The English equivalent for the German name may be rendered as *Lovely-toned Covered Stop;* and good examples richly merit such a title. While all the forms in which the LIEBLICHGEDECKTS are made have certain features in common, they present some distinctive treatments which we shall attempt to illustrate and describe.

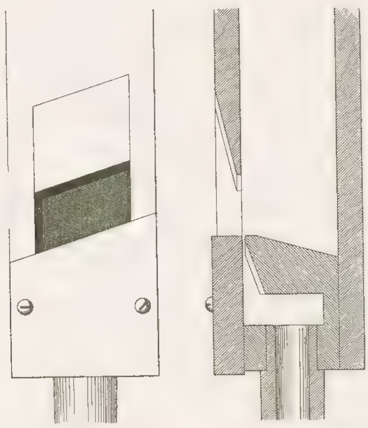


FIG. CCLXIX.

In the first place, they vary considerably in scale, while all are characterized, in comparison with the other covered stops of the Organ, by smallness: and the scales vary not only in size generally, but also in the proportions of width to depth, the softer varieties being narrow in proportion to their depth, while the stronger-toned have proportionally wider mouths,* reaching their maximum width in the rarely-used square pipes.

The largest scale to be recommended for the unison CC pipe of the true LIEBLICHGEDECKT is 3¼ inches in width by 4 inches in depth; but a smaller scale is more generally useful. The three stops of this class in the Organ in St. Peter's Church, Hindley, are of the following scales: the CC pipe of the Great Organ GEDECKT measures 2⅞ inches by 3⅞ inches, having its mouth 2⅞ inches by 2

* In speaking of the width of a pipe, we invariably allude to the internal dimension of the side in which the mouth is cut. A pipe may, therefore, be described as having a greater depth than width, or greater width than depth, according to the location of its mouth.

inches; the corresponding pipe in the Swell Organ GEDECKT measures 2⅛ inches by 3 inches, having its mouth 2⅛ inches wide by 2¼ inches high; and the LIEBLICHGEDECKT in the Choir Organ measures 2⅛ inches by 3⅛ inches, having its mouth 2⅛ inches by 1½ inches. The range between the maximum given and the smallest of the above scales, as used by Schulze, practically covers all the dimensions suitable for the CC pipe of the stop. From the width and depth decided on, the scale can be developed by halving on the seventeenth note above, or in the ratio 1 : 2·66.

The height of the mouth is a most important factor in the production of the characteristic normal flute-tone of the LIEBLICHGEDECKT. In no case should it be less than half its width in height; and, as in the case of the stop in the Swell division of the Hindley Organ, it may exceed its width in height. In the smaller scales, the square mouth may be used with a perfectly satisfactory result. The accompanying illustration, Fig. CCLXX., shows the Front View and Section of the mouth and lower portion of a LIEBLICHGEDECKT pipe, having a square, German mouth. The thickness of the upper lip is another important factor in the tone production. This may vary from a quarter to half an inch (the thicker producing a rounder tone), and be cut square or have rounded edges; and the lip may be straight, as in the illustration, or arched, as the voicer deems expedient. All these details must be decided before the pipes are made. Pipes having mouths of so great a height in proportion to width require a copious supply of wind for their proper speech; and, accordingly, their feet should have large holes. The CC pipe should have a hole an inch in diameter. The stoppers should be made of slices cut from the block-wood, and treated as in the case of those for the so-called STOPPED DIAPASON.

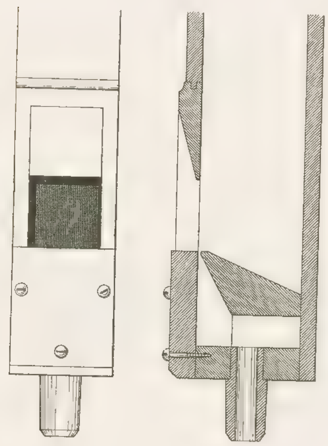


FIG. CCLXX.

It is quite a common practice to use metal pipes for the higher octaves of the unison LIEBLICHGEDECKT, for it is found that there the tone of the wood pipes can be closely imitated by covered metal ones. All the GEDECKTS in the Hindley Organ, for instance, have metal treble pipes.

Valuable as are the LIEBLICHGEDECKTS of 8 ft. tone, they are not more so than those of 16 ft. tone. For insertion in Choir and Swell divisions the latter are in every way suitable. They should be entirely of wood, or if metal is used it should not go below the top octave. Dr. Hopkins gives a scale for a Choir or Swell LIEBLICHGEDECKT, 16 FT., apparently of German origin. The CCC pipe is 3⅜ inches in width by 5 inches in depth; the CC pipe is $2\frac{3}{16}$ inches in width by 3 inches

in depth; and the C pipe is 1⅜ inches in width by 1⅞ inches in depth. This scale is remarkable for its irregularity: each octave seems to have a ratio of its own, if ratios have been used at all in its formation. It approaches most closely to the standard ratio, 1 : 2·519.

In form and treatment the wood pipes of the LIEBLICHGEDECKT, 4 FT., are similar to those of the unison stop; but it is seldom that more than the lowest octave is made of wood, while it is quite a common practice to form the entire stop of metal.

The smaller wood pipes of the LIEBLICHGEDECKT, or, say, those above the pipe yielding the 4 ft. tone, should be fronted with hardwood, while the larger pipes may have the hardwood confined to their mouths, as indicated in Fig. CCLXX.

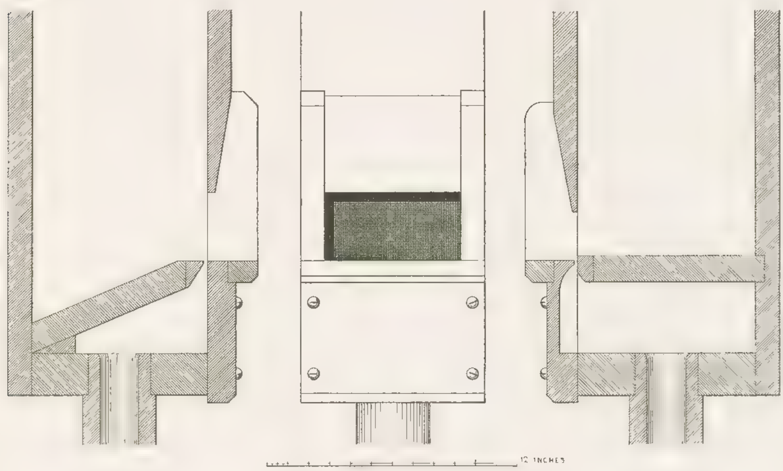


FIG. CCLXXI.

BOURDON.—The construction of the pipes of the ordinary BOURDON does not differ materially from that of the STOPPED DIAPASON, as above described; and the materials used may be the same. The larger size of the stop, which is of 16 ft. tone, renders the use of solid blocks undesirable save in the upper octaves. The BOURDON proper varies greatly in scale, chiefly because it is inserted in both the pedal and manual departments of the Organ. The most suitable scales for the Pedal Organ stops range from a width of 8½ inches by a depth of 10 inches to a width of 5¾ inches by a depth of 8 inches for the CCC pipe, all scales halving on the sixteenth pipe—ratio $1 : \sqrt{8}$. The latter scale has been adopted by Schulze in the Pedal department of the Hindley Organ, the CCC pipe having a mouth 4 inches high. The scale of 6½ inches by 8½ inches is ample for all ordinary Church

Organs with properly-appointed Pedal departments; and 4 inches by 5½ inches is a suitable scale for a true Chamber Organ. Larger scales than the maximum above given have been frequently used; but they are neither necessary nor to be recommended. In most instances the pipes have low mouths, rarely exceeding one third their width; and their tones are tubby and often unmusical in the extreme. In the accompanying illustration, Fig. CCLXXI., are given the Front View and two Sections of the mouth and lower portion of a BOURDON pipe, according to the medium scale above recommended. The Section on the left of the Front View shows the mouth of the German form, one-half its width in height, with straight and thick upper lips, ears of medium projection, and a bearded cap. The Section on the right has the ordinary English mouth. The internal construction of both forms is clearly shown.

The scales of the manual BOURDON, 16 FT., may range from a width of 5 inches by a depth of 7 inches to a width of 3⅞ inches by a depth of 6⅜ inches. The latter are the dimensions of the lowest (CCC) pipe in the Great division of the Hindley Organ, the mouth of which pipe is 3⅛ inches in height. The LIEBLICH-BOURDON in the Swell division of the same instrument has its lowest pipe measuring 3⅜ inches by 5 inches, with a mouth 3¾ inches high. The tone is round and full.

The mouths of the BOURDONS usually made by English builders are seldom over one-half their width in height, and are often less than one-third. Their tones, accordingly, have the twelfth, or first harmonic of a stopped pipe, more or less prominent, approaching in some cases to the QUINTATEN in tone. These pipes have the ordinary English mouth, with the horizontal languid, similar to that shown in the right Section in Fig. CCLXXI. On the other hand, the BOURDONS and LIEBLICHBOURDONS of the German builders have their mouths cut up very high, rising from about a height of two-thirds their width to a height exceeding their width, as exemplified by the stop in the Hindley Organ, the dimensions of which have just been given. It is true that certain English builders have during recent years learnt valuable lessons in pipe-making and voicing from German work, to the great improvement of tonal coloring. We accordingly meet with BOURDONS, in some of the better class of English Organs, which have all the characteristics of German stops; namely, small scales, high mouths, flush lower lips, thick upper lips, and copious wind-supply.

The tones produced by small-scaled and high-mouthed BOURDONS are fuller and purer than those yielded by the large-scaled and low-mouthed English stops: and this fact, combined with the comparatively small standing room they require, makes them most suitable for insertion in the manual divisions of the Organ, and especially those enclosed in swell-boxes. The tone of the BOURDON pipe is also affected by the thickness of the upper lip of its mouth, which varies from a quarter of an inch to nearly an inch in different examples. The lowest pipe of the BOURDON in the Great division of the Concert Organ in the Public Halls, Glasgow, measures 5⅛ inches in width by 6⅜ inches in depth, having a mouth 3⅞ inches high, with a square-cut upper lip $\frac{11}{16}$ inch thick. The tone of the BOURDON pipe is also affected by the form of the upper lip, which may vary, according to the taste of the voicer, from the straight line to an arch approaching a semi-circle. In Fig.

CCLXXII. are given a Front View and Section of the lower part of a manual BOURDON pipe. The mouth is of the German class, with sloping languid, and with a thick and arched upper lip. The scale here observed is that of a CCC pipe, 4¼ inches wide by 6 inches deep, with a mouth two-thirds of its width in height. As all the high-mouthed GEDECKTS require a copious supply of wind, care must be taken to provide the BOURDON pipes with large feet: the CCC pipe should have a foot with a hole from 1¼ inches to 2 inches in diameter, according to requirements, and the rest of the pipes in proportion. There must be no stint in the matter of wind.

It is quite a common practice, especially with French and German organ builders, to insert the upper octaves of the BOURDON in metal. The BOURDON, 16 FT., in the Great division of the Armley Organ is of wood to b^1, and thence to the top=25 notes, in covered pipes of metal. The three manual BOURDONS in the Concert Organ in the Town Hall, Manchester, constructed by Cavaillé-Coll, of Paris, have pipes of wood up to the pipe yielding the 4 ft. note, where they break into large-scale, covered pipes of metal. Numerous other instances could be mentioned. We, however, fail to see any advantage to be gained by using metal in so large a stop, having a distinctive voice; and we strongly recommend carrying the stop, throughout the compass of any division in which it is placed, in wood pipes: the true character, regularity, and mixing quality of its tone will be secured by this sameness of form and material. The second BOURDON in the Great division of the Manchester Town Hall Organ is of 8 ft. pitch, and has its bass octave only of wood pipes. This would not have been so objectionable had the first BOURDON, 16 FT., in the same division, been of wood throughout. We do not think that these examples should be looked upon as anything save negative object lessons; for the totally inadequate provision made by the architect for the reception of an Organ, even of modest size, compelled Cavaillé-Coll to resort to every expedient known to him to economize in the horizontal dimensions of his instrument, and doubtless the treatment of the BOURDONS was one, and by no means the worst, of the expedients resorted to.

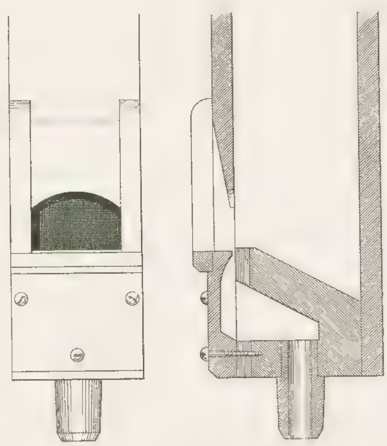


FIG. CCLXXII.

DOPPELFLÖTE.—We now come to what is probably the most useful and beautiful normal flute-toned stop in the Organ, commonly known under the Ger-

man name of DOPPELFLÖTE, and which, in English, may be called the DOUBLE-MOUTHED FLUTE. It is somewhat surprising that so fine a stop should have been so systematically neglected by English organ builders; and it is equally remarkable that in none of the several Organs built for England by the great Schulze is there a single specimen of the stop. In the year 1883, the late Hilborne L. Roosevelt, of New York, presented the writer with a DOPPELFLÖTE for his Chamber Organ; and so far as we can learn this was the first stop of the kind inserted in an English Organ. The stop—most beautifully made of white pine, fronted with mahogany, and varnished—was voiced by his talented voicer, Mr. Charles Engelfried.

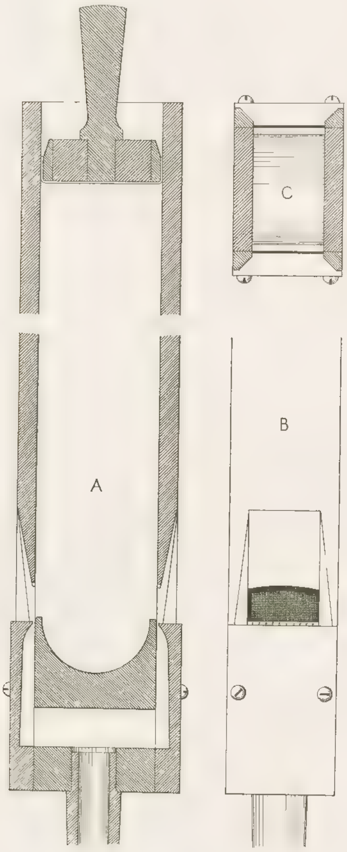


FIG. CCLXXIII.

The tone of the DOPPELFLÖTE when properly voiced is singularly full and round, having more filling-up power and better mixing qualities than any other covered stop in use; and these facts are surely sufficient to recommend it for insertion in every Organ of any pretensions toward completeness. Its value has been fully recognized by the Roosevelts and other leading American builders; the former rarely omitted it from the Great divisions of their fine Organs. We are afraid, as the stop is more expensive and troublesome to make than an ordinary STOPPED DIAPASON or LIEBLICHGEDECKT, that few English organ builders will voluntarily advocate its use; but it should certainly find a place in every Organ, being, for general utility, next in value to the PRINCIPAL, 8 FT. The DOPPELFLÖTE is specially useful with reed stops of all classes, imparting to their tones fulness and body without destroying their character. No other stop in the Organ combines with the CLARINET in so satisfactory a manner.

The DOPPELFLÖTE is invariably of 8 ft. pitch, and is formed of wood throughout. The bass octave is of single-mouthed GEDECKT pipes, of medium scale, voiced to yield a full tone, which carries down the characteristic quality of the more important portion of the stop in a fairly satisfactory manner. From tenor C to the

top, each pipe has two mouths, placed on each side of a block in which a semicircular depression has been cut. The mouths are otherwise of the English form, having splays cut in their side-pieces, and slightly arched upper lips. These and all other details are accurately shown in the accompanying illustration, Fig. CCLXXIII. In the drawing A is given a Longitudinal Section of a pipe, cut through the mouths, and showing the forms of the block and caps. Above is given the section of the stopper, edged with cork, and covered with soft leather. A Front View of one of the mouths is given in the drawing B, showing the proportionate height of mouth, the arch of the upper lip, and the lateral splays. At C is a Transverse Section through the mouths, showing the depression in the block, the wind-ways, and the upper ends of the caps. The wind-ways are indicated by the thick black lines. All the parts are drawn in correct proportion.

The pipes of the Doppelflöte, having the double mouths, require a scale allowing a considerable depth in proportion to width. This can be seen from the following measurements, taken from the standard scale used by Roosevelt: Tenor C, $2\frac{1}{4}$ inches in width by $3\frac{7}{16}$ inches in depth; middle c^1, $1\frac{3}{8}$ inches by $2\frac{8}{16}$ inches; and c^2, $\frac{3}{4}$ inch by $1\frac{7}{16}$ inches. It will be observed that the proportions of depth to width vary as the scale ascends, the C pipe being a little over one and a half its width in depth, while the c^2 pipe is a little under twice its width in depth. The height of mouth, at the spring of its arched upper lip, ranges between one-third and one-half its width, according to the wind-pressure and strength of tone required. In making the pipes the upper lips are left straight, the arching being executed subsequently by the voicer. As the pipes have two fronts, they must be put together in the manner indicated at B in Fig. CCLVIII. Their sides, which should be of the finest spruce, must be glued to the blocks in the first instance; the fronts of mahogany, pear, or maple are glued on, one after the other. The mouths may be cut either before or after the fronts are attached. The pipes having mouths of moderate height do not require a great flow of wind, nevertheless their feet should be of good size: the bore of that of the C pipe should not be less than $\frac{3}{4}$ inch.

A powerful-voiced open wood stop of normal flute-tone has been made with double mouths, in a similar manner to the Doppelflöte, but it has not been commonly approved of or often used. We believe that although the stopped Doppelflöte appears in every important Organ Roosevelt built, he only introduced the open Doppelflöte in one instrument, under the somewhat inappropriate name of Philomela. In the three largest suggested Specifications given in his handsome *brochure*, the Philomela is placed among the Solo Organ stops. Should this stop be used it should bear a more expressive name, for it is difficult to associate its powerful voice with the sweet notes of the Nightingale (*Daulias philomela*). Clarke, in his "Outline of the Structure of the Pipe Organ," describes the Philomela as of "Small-scale, stopped wood pipes, voiced with the sweetest and most delicate quality." The name in this case is about as appropriate as most fancy names can claim to be.

Seraphonpfeife.—It would have been a somewhat remarkable fact in the history of organ-building had no attempt been made to construct pipes with double mouths placed on adjacent sides, or as close together as practicable. How often

such an attempt has been made has not been recorded, but in the so-called SERAPHONPFEIFE we have a positive example of the treatment. In the accompanying illustration, Fig. CCLXXIV., are given a Front View and Transverse Section of the wood SERAPHONPFEIFE, said to have been invented by Mr. G. F. Weigle. The pipes forming this stop are square and have two mouths of the ordinary inverted form cut in two adjacent sides, as indicated at A and B, furnished with the caps C and D. This pipe is simply a variation of the DOPPELFLÖTE; but, on account of its square form, and the greater dimensions of its combined mouths in proportion to its internal transverse area, it is capable of producing a tone of much greater power than is either possible or desirable in such a pipe as is commonly scaled for the DOPPELFLÖTE.

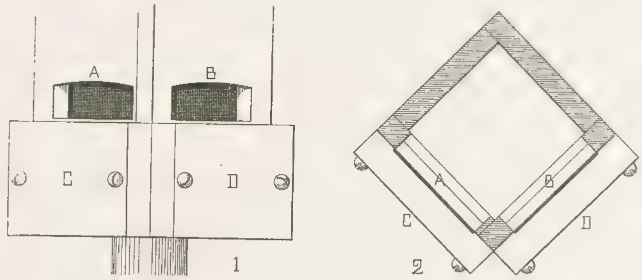


FIG. CCLXXIV.

When properly voiced on high-pressure wind, the SERAPHONPFEIFE, 8 FT., is capable of yielding a commanding tone of great body, suitable for a large Solo Organ, where its voice would greatly enhance the value of the high-pressure reed stops. In power it would equal and probably exceed that of the loudest STENTORPHONE, while in character of voice it would be a decided contrast, especially when constructed as a covered stop, like the DOPPELFLÖTE. For strength of tone the SERAPHONPFEIFE has to be formed of large-scale open pipes.

FLAUTO D'AMORE.—This is a small-scale stop of 4 ft. pitch, the pipes of which, in general form, resemble those of the LIEBLICHGEDECKT, but differ from them in having lower mouths and pierced stoppers. These peculiarities separate the FLAUTO D'AMORE from the true LIEBLICHGEDECKT and LIEBLICHFLÖTE, 4 FT., and impart a delicate and peculiar tonality to the stop. The FLAUTO D'AMORE can be made with the inverted mouth if desired, its tone being somewhat keener. Both mouths are shown in the Longitudinal Sections given in Fig. CCLXXV. Two forms of stoppers are also shown: that at A, being cut from solid wood, is the most suitable for the smaller pipes; while that at B, having a turned and inserted handle, is adapted for the larger pipes of the lowest octave. As the perforations in the stoppers affect the quality of the tone, their lengths must of course

be graduated regularly throughout the stop: and as this gradation of length would make the stoppers of the higher octaves inconveniently short, if treated as at A, long stoppers must be provided, perforated transversely with as large a hole as possible. At C is shown a Section of such a stopper, with this larger transverse hole shortening the smaller vertical one at the necessary point. The diameters of the vertical perforations may vary in size according to the scale of the pipes and the quality of tone desired. The largest pipes may have a perforation of about 3/8 inch. All the perforations must be cleared and hardened by burning with red-hot

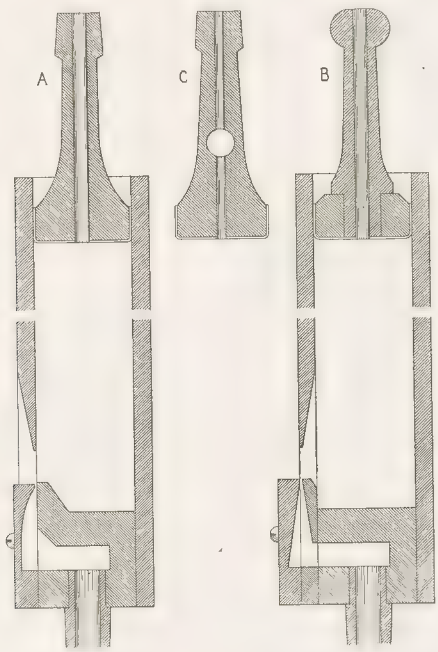


FIG. CCLXXV.

wires of proper sizes. The FLAUTO D'AMORE pipes require for their most characteristic tones a comparatively small supply of wind, and speak best on a pressure of about 2½ inches.

FLAUTO DOLCE.—Under such names as FLAUTO DOLCE, FLÛTE DOUCE, SANFTFLÖTE, and ZARTFLÖTE, several forms of stops have been made, producing normal flute-tones whose chief characteristic is softness. As the pipes forming the generality of these stops present no special features differing from those already described and illustrated, we pass them over, reserving one form for consideration which does present a feature that has not been mentioned. This may be named, in

allusion to the special feature in its construction, the CYLINDER-LIPPED FLUTE. The formation of the mouth, block, and cap is distinctly shown in Fig. CCLXXVI. It will be observed that the upper lip of the pipe has a cylindrical piece of wood attached to it, against the rounded surface of which the wind-sheet acts in its vibratory motion: and it is evident that the remarkably smooth and soft quality of the tone is largely due to the thick cylindrical lip. The pipes are made five-sixths of their width in depth, as indicated in the illustration; and their mouths are rather more than one-third their width in height. A stop of 8 ft. pitch, formed of these pipes, would be admirably suited for a Choir or Chamber Organ.

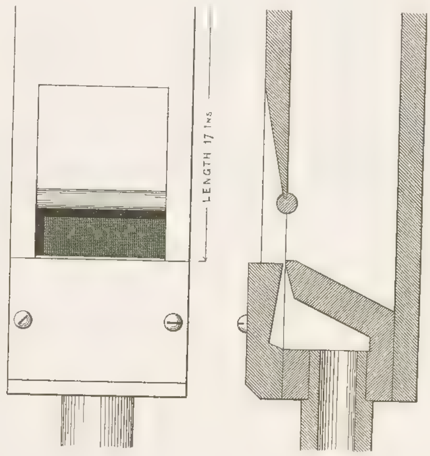


FIG. CCLXXVI.

There are other stops of normal flute-tone known by special names; but as the general forms and construction of their pipes do not present features varying essentially from those already described and illustrated, we need not consider them here. They will be found briefly described in the Chapter on the Names and General Particulars of Organ Stops. We shall now direct the student's attention to the forms and construction of wood pipes yielding imitative flute-tone.

ORCHESTRAL FLUTE.—As there are only two Flutes used in the Orchestra; namely, the Flauto Traverso and Flauto Piccolo, the range of imitative flute-tone is naturally circumscribed; and the forms of the organ stops or pipes which have been invented for the purpose of imitating the tones of the orchestral instruments are accordingly few in number. As it was found impossible to produce the pure, liquid, and penetrating tones of the orchestral Flute from pipes of the ordinary form, having quadrangular mouths, the peculiar form of the embouchure and the method of sounding the orchestral instrument were carefully studied with the view of imitating them, to as full an extent as practicable, in the organ pipe. The Flute

was first brought to reasonable perfection in Germany, to be thenceforth known as the German Flute; and the most successful imitative flute-toned stops were likewise devised in that country.

There are three forms for the bodies of wood pipes used for the ORCHESTRAL FLUTE or FLAUTO TRAVERSO stops; viz.: cylindrical, quadrangular, and triangular. The first is not uncommon in good German work, but rarely, if ever, used by the builders of other nations, who are content with simpler methods of construction, even though the tones produced are unsatisfying from the strictly imitative point of view. The quadrangular form is most frequently used, and is, under certain treatments, highly satisfactory; and the triangular form of body is that most rarely met with in Organs.

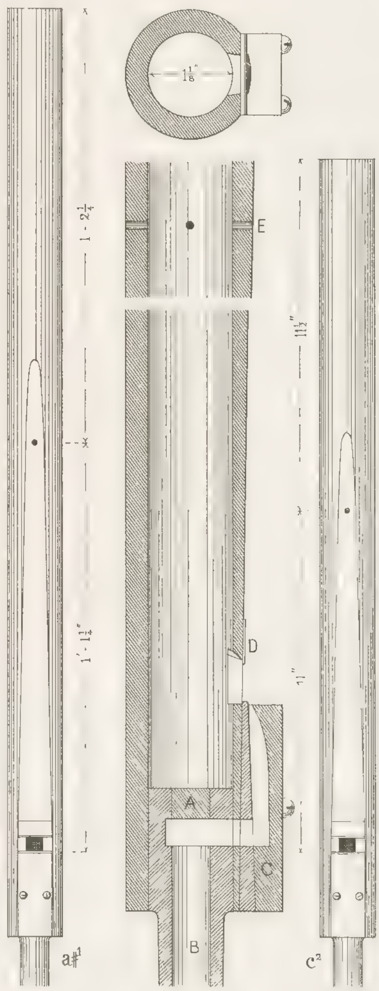


FIG. CCLXXVII.

The pipes which have proved the most imitative in their tones are those which most closely resemble the orchestral Flute in form. They are constructed of cylindrical tubes of hardwood, with mouths of small size, placed in relation to their blocked ends just as is the embouchure of the orchestral instrument. The formation of their caps is such that the wind is directed obliquely against the face of their upper lips, just as the wind from the human mouth is directed across the embouchure of the Flute. The cylindrical pipes are invariably harmonic, and accordingly about double their true speaking length; and they are only introduced in the higher octaves of the stop, quadrangular pipes being used for the lower octaves. Fine examples, under the name of FLAUTO TRAVERSO, are to be found in Schulze's work in the Doncaster Parish Church and Leeds Parish Church Organs. As both stops are practically alike, a description of that in the latter Organ will be sufficient.

The stop is of 8 ft. pitch but is not carried down below tenor C. The cylindrical, harmonic pipes commence at a♯[1] and extend to the top. They are of beech wood, carefully and cleanly bored, and turned externally. We presume the builder, reasoning on the fact that all the notes of the orchestral Flute are produced from a single tube, considered it unnecessary to graduate, in the usual manner, the diameters as well as the lengths of all his pipes; for we observe in the Flauto Traverso under consideration, that several groups of pipes of similar diameters obtain. No apparent irregularity of tone results from this absence of regular gradation, herein showing the skill of the voicer. In the accompanying illustration, Fig. CCLXXVII., are given Front Views of the a♯[1] and c[2] pipes, both of which have the same internal diameter of 1⅛ inch: all the other important dimensions are furnished. Each pipe has a slant planed off one side, extending from a little above its center to the foot, in which the mouth is cut, and against which the cap is placed. The mouth is a small square perforation cut in the slant; and owing to the difficulty of cutting an internal slope from the outside, the voicer has found it necessary to form the upper lip with a piece of hard cardboard, glued across the slant, and pared thin, and in some cases slightly arched, at the mouth. This is indicated in the drawings. The block and pipe-foot are turned from a single piece of wood, a piece being cut out to form the throat, as shown in the Longitudinal Section. Another method is sometimes adopted: the pipe is plugged with a cork at about the distance below the mouth equal to the internal diameter of the pipe, and below this plug is inserted the turned pipe-foot, leaving a sufficient space between for the passage of the wind into the cap, through a hole cut in the slant for that purpose. The proper form of cap for this description of pipe is that which directs the wind-sheet in a slanting direction across the mouth, as already mentioned. The cap is constructed of two pieces; namely, the cap proper, hollowed on its inner side, and having the wind-way cut in it; and a thin wedge-shaped piece of wood, slightly longer than the cap proper, and rounded along its thinner edge, used for the purpose of holding the cap in a sloping position slightly above the slanting surface of the pipe. All these details are accurately shown in the two Sections given in Fig. CCLXXVII., both of which are cut through the mouth of the pipe. A is the block; B the pipe-foot; C the cap, constructed of two pieces, as above described; and D is the strip of cardboard forming the upper lip of the mouth. All the cylindrical pipes are harmonic, and, accordingly, are made about twice their true speaking lengths; and to secure their promptly speaking the harmonic notes, they are perforated, near their nodal lines, with four small holes, as indicated in the Front Views and at E in the Longitudinal Section. The pipes are tuned by metal shades at top.

To construct a cylindrical wood pipe the following method should be followed. Take a square piece of beech or some other straight-grained hardwood of the necessary length and somewhat thicker than the finished diameter of the pipe, and bore it throughout its length with a very sharp and clean-cutting auger-bit, care being taken to have the hole straight and directly along the axis of the piece. Then, after making the inside perfectly smooth with sandpaper glued to a round rod of wood nearly the size of the bore, the piece is plugged in a temporary man-

ner, fitted in a lathe, and turned to the desired diameter. It is then cut in the lathe to the desired length, after which it is ready to have the face-slant planed from it, and the mouth and wind-hole cut. No further directions are necessary for the cork-plugging, fixing the foot, and making the harmonic perforations. Our subsequent remarks on the other forms of ORCHESTRAL FLUTE pipes will supply any missing points for the instruction of the student. From tenor C to a^1 the pipes of the FLAUTO TRAVERSO in the Leeds Organ are square, with narrow and slightly arched inverted mouths, and caps of the same construction as those of the cylindrical pipes.

Töpfer, in giving a scale for the higher octaves of the FLAUTO TRAVERSO,* appears to advocate the use of wood pipes with a taper bore; and by adopting this form the diameters of the pipes can be graduated in a satisfactory manner. It is only necessary to use reamers of sufficient length and different sizes to gradually enlarge the auger holes to the proper scale at the mouth-line of the pipes. Although this will not produce taper bores absolutely correct, it will make them much closer to a true scale than the irregular method adopted by Schulze. The scale given by Töpfer is one recommended by Friedrich Haas, the builder who reconstructed the celebrated Organ at Lucerne. It is given in millimetres as follows:

FRIEDRICH HAAS' SCALE OF THE FLAUTO TRAVERSO.

PIPE.	DIAMETER UNDER MOUTH.	DIAMETER AT TOP.	DIAMETER OF MOUTH.
c^1. 2 ft. tone	34·5 mm.	24·6 mm.	17·4 mm.
c^2. 1 ft. tone	26·4 "	18·9 "	14·1 "
c^3. ½ ft. tone	19·5 "	14·4 "	11·1 "
c^4. ¼ ft. tone	13·8 "	10·5 "	7·2 "

The mouths of these pipes are to be circular, and slightly splayed away on the inside; and about one-half of them are covered by the inner portion of the cap. The two lower octaves—CC to B—are to be of square open pipes of true speaking lengths, having semicircular or oval-shaped mouths; and their caps are to be of the compound form previously described and clearly shown in Fig. CCLXXVII. The CC pipe is to measure 84 mm. (3·3 inches) square.

The form of ORCHESTRAL FLUTE we are now going to describe produces, when carefully made and voiced, a quality of tone almost equal to that yielded by the German cylindrical stop. It has the advantage of being more easily constructed, while it admits of being accurately scaled throughout. The pipes are harmonic from F, are quadrangular and nearly square in form, and have circular mouths and compound caps. The construction of the lower portion of a pipe is accurately delineated in Fig. CCLXXVIII., which is drawn from a c^1 pipe made by Roosevelt, the stop being of 4 ft. pitch. The scale of the F pipe is 1⅛ inches in width by 1⅜ inches in depth; and that of the c^1 pipe $\frac{13}{16}$ inch in width by $1\frac{1}{16}$ inches in depth. The former pipe has a mouth $\frac{11}{16}$ inch in diameter; and its single

* "Die Theorie und Praxis des Orgelbaues." Weimar, 1888; page 241.

harmonic perforation, ⅛ inch in diameter, placed $13\frac{9}{16}$ inches from the top of the mouth. The c[1] pipe has a mouth $\frac{9}{16}$ inch in diameter, and its harmonic perforation, a little under ⅛ inch in diameter, placed 8¾ inches from the top of the mouth. The full length of the c[1] pipe, from the top of the mouth, is 22¼ inches, while the total internal length of the pipe, from the sunk block, is 23½ inches. It will be seen on reference to the Longitudinal Section A in Fig. CCLXXVIII., that the circular mouth is hollowed on the inside so as to leave a thin rim for the wind to play over; and that the construction of the compound cap is such as to direct the wind-sheet across the mouth at a considerable angle. As the form and size of the wind-way has to be carefully adjusted, and so that it shall not alter in

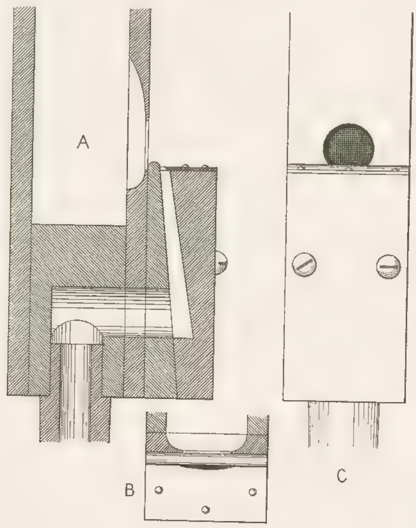


Fig. CCLXXVIII.

moist or dry weather, it is cut in a thin plate of brass, which is pinned to the top of the outer part of the cap. The position of this plate is shown in the Longitudinal Section A; and the form of its wind-way is given in the Transverse Section through the mouth, B. The position of the rounded upper edge of the wedge-shaped part of the cap with relation to the circular mouth is accurately delineated both in the Longitudinal Section and in the Front View C. In voicing pipes of this kind, three things have to be considered; namely, the thickness of the wedge piece, the size of the wind-way, and the position of the cap with relation to the circular mouth: all are factors of importance in the production of a perfect intonation. No attempt should be made to fix the cap, either by glue or screws, until the correct position has been determined on the voicing machine. The pipes that are harmonic should preferably be made of pear or maple; and on no account should

white pine be used for their fronts, although it, or spruce, may be employed for their sides and backs. The caps are best made of beech. As the pipes do not call for a great supply of wind, their feet need not have bores of large size: that of the lowest harmonic pipe may be ½ inch in diameter, which will allow of plugging for regulation.

The larger, non-harmonic pipes, from CC to E, are of true speaking lengths, have narrow inverted mouths, and compound caps made of beech, without brass wind-way plates. As the ordinary orchestral Flute does not sound below middle c^1, the 4 feet octave cannot be considered imitative: yet as there is a Bass Flute, of recent invention, which goes an octave lower than the ordinary orchestral instrument, it behooves the voicer to do his utmost to carry the true flute quality throughout the compass of the stop. This can be satisfactorily done with non-harmonic pipes.

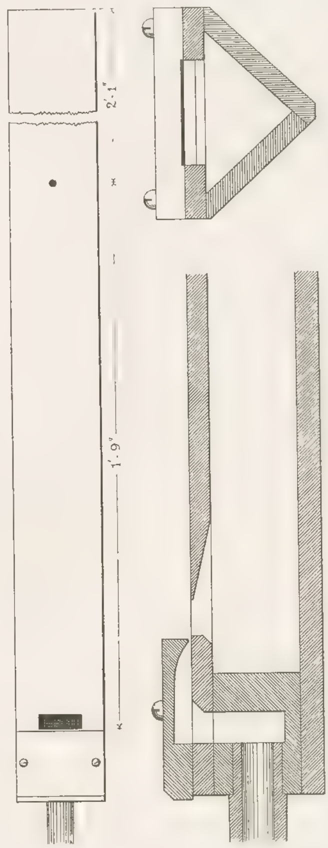


Fig. CCLXXIX.

The harmonic pipes of the Orchestral Flute or Flauto Traverso, 4 ft., have occasionally been made of triangular form, but apparently without any special advantage in the important matter of tone. A good example is to be found in the Echo division of the Concert Organ in the Town Hall, Leeds, built in 1858 by Gray & Davison, of London. The harmonic, triangular pipes commence on the tenor C key, where, as the stop is of 4 ft. pitch, the pipe yields the 2 ft. note. They extend to the top. The lowest octave is of non-harmonic pipes which do not call for any particular description. The form and construction of the triangular pipes are shown in Fig. CCLXXIX., in which are given a Front View and Longitudinal and Transverse Sections of the largest one. It will be observed that the width of the pipe is considerably in excess of the depth in measurement, in this respect differing from the triangular Hohlflöte, illustrated in Fig. CCLXVIII., in which the depth is greater than the width. The following are the dimensions of the three pipes yielding the 2 ft., 1 ft., and ½ ft. notes, as accurate as we could obtain them in the Organ:

C, 2 ft. pitch,—width 2 ¾ inches; depth along sides 2 inches; length from cap 3 feet 10 inches; distance of harmonic perforation from cap 1 foot 9 inches; diameter of perforation ¼ inch; width of mouth 1 ⅜ inches; height of mouth $\frac{9}{16}$ inch; and block sunk below mouth ¾ inch: c^1, 1 ft. pitch,—width 1 ⅞ inches; depth along sides 1 ⅜ inches; length from cap 1 foot 10 inches; distance of harmonic perforation from cap 11 inches; diameter of perforation $\frac{3}{16}$ inch; width of mouth ⅞ inch; height of mouth $\frac{5}{16}$ inch; and block sunk below mouth ⅝ inch: c^2, ½ ft. pitch,—width 1⅛ inch; depth along sides $\frac{15}{16}$ inch; length from cap 10 ¾ inches; distance of harmonic perforation from cap 5 $\frac{1}{16}$ inches; diameter of perforation ⅛ inch; width of mouth ⅝ inch; height of mouth $\frac{7}{32}$ inch; and block sunk below mouth $\frac{7}{16}$ inch. The wind pressure is 2½ inches; and the tone of the stop is pure and of medium strength.

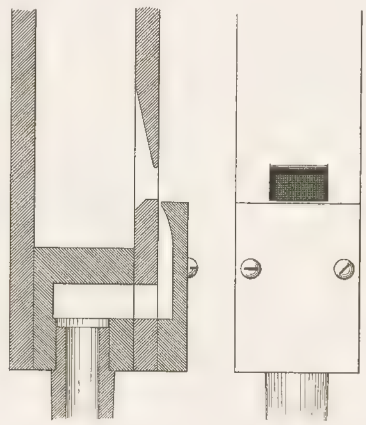


Fig. CCLXXX.

A very effective Orchestral Flute, 4 ft., may be made of pipes of quadrangular form, with mouths constructed in the simple manner shown in the accompanying illustration, Fig. CCLXXX. The pipes may vary in scale, be made of greater depth than width, or be made square, according to the strength of tone required. The mouths should be about three-fifths the widths of the pipes, and about three-fifths their widths in height, or of the proportions shown in the drawing. The pipes should be made harmonic from tenor C, 2 ft. pitch—the lowest note of the true orchestral Flute; but for a soft Flute for a Choir or Chamber Organ they may be made non-harmonic throughout.

Harmonic Flute.—The wood stop commonly labeled Harmonic Flute, and occasionally, on account of its strongly imitative tone, Flauto Traverso, appears of both 8 ft. and 4 ft. pitch. In the unison stop, the bass octave is generally of Lieblichgedeckt pipes; the seventeen pipes from C to e^1, inclusive, are of open

unison lengths; and from f^1 to c^4, inclusive, the pipes are harmonic, and, accordingly, of double lengths. In the octave stop, from CC to E the pipes are of open unison lengths; from F to c^3 the pipes are harmonic; and from $c\sharp^3$ to c^4 the pipes are harmonic and made of metal. The scale of the lowest open non-harmonic pipe, in both stops, is $2\frac{1}{4}$ inches in width by $2\frac{3}{4}$ inches in depth; and that of the highest non-harmonic pipe is $1\frac{3}{16}$ inches in width by $1\frac{7}{16}$ inches in depth. The lowest harmonic pipe, made double length, is $1\frac{1}{4}$ inches in width by $1\frac{1}{2}$ inches in depth; and the highest harmonic pipe of wood is $\frac{3}{8}$ inch in width by $\frac{15}{32}$ inch in depth. The mouths of all the pipes are inverted, are of the full widths of the scale, and are one-third of their width in height. Their caps are of the ordinary hollowed-out form and are depressed slightly below the lower lips of the mouths. In all essentials, the formation of the blocks, caps, and mouths resembles that shown in the Section in Fig. CCLXXIX., and need not be specially illustrated.

Orchestral Piccolo.—As the Orchestral Piccolo, 2 ft., is simply an Octave of the Orchestral Flute of 4 ft. pitch, its pipes are constructed in precisely the same manner as those of the imitative flute-toned stops just described. The Orchestral Piccolo being, in its proper form, a solo stop, the scale of its pipes should be similar to, or perhaps two pipes smaller than, the scale of the corresponding octaves of the Orchestral Flute. The stop should be of harmonic pipes throughout, the wood pipes extending from the bottom note to e^2, and metal ones from f^2 to the top. There will be an advantage in the matter of construction, and no disadvantage in tonal effect, attending this arrangement; for in notes of so high a pitch, the tones from wood are not in any way superior to those produced from metal pipes; and there is more than one practical reason in favor of the adoption of metal pipes in the octaves of high pitch.

WOOD PIPES OF STRING-TONE.

Of all the wood stops that have been invented perhaps those which yield imitative string-tone are the most noteworthy and interesting. One can readily understand the production of both pure organ-tone and flute-tone from wood pipes; but the problem of producing sounds from such pipes strongly imitative of the compound and penetrating tones of the orchestral bowed instruments, would appear to be surrounded by insurmountable difficulties. That those who first essayed the task of making and voicing such imitative pipes found it difficult, is amply proved by the small success which attended early efforts. The problem seems to have been first completely solved by the great Schulze. At all events, in our long study of the art of organ-building, and during our personal examination of hundreds of representative Organs distributed throughout Germany, Switzerland, Belgium, Holland, France, Italy, and England, we have discovered no string-toned stops at all comparable to those made and voiced by Edmund Schulze, of Paulinzelle. It is quite certain that wood stops of imitative string-tone were unknown in England prior to the advent of the organs constructed by Schulze: notably those in the Parish Church of Doncaster and St. Peter's Church, Hindley. In the numerous pages of "The Organ," by Hopkins and Rimbault, published in 1870, string-

toned wood stops are not even mentioned; indeed the VIOLA DA GAMBA, in its old-fashioned treatment in metal, is the only stop of string-tone described. This proves that up to a late date English organ builders and organ experts knew nothing of the nature and powers of wood pipes producing imitative string-tone.

DOUBLE BASS.—Of all the wood stops of string-tone, known to us, that which best deserves the name of DOUBLE BASS is the stop labeled VIOLONBASS, 16 FT., in the Hindley Organ. The tone of this stop is imitative to a remarkable degree, extending even to the rasping effect of the bow on the strings. The pipes are of

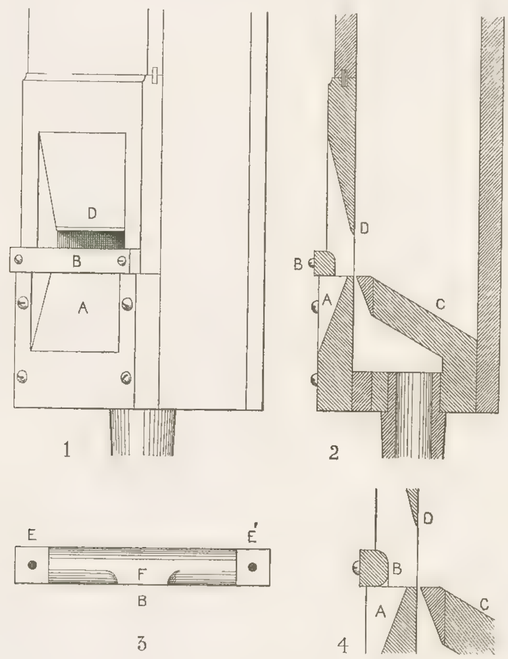


FIG. CCLXXXI.

small scale, square in section, and furnished with sunk blocks, caps with an external inclined sinking, and harmonic-bridges. The accompanying illustration, Fig. CCLXXXI., shows the forms and arrangement of the several parts constituting the speaking portion of the CCC pipe, accurately drawn to scale. Diagram 1 is a Diagonal View of the lower portion of the pipe, showing all the parts belonging to the mouth in position; Diagram 2 is a Longitudinal Section of the same, through the center of the mouth; Diagram 3 shows an Enlarged View of the inner face of the harmonic-bridge, and Diagram 4 a Section of the mouth, clearly indicating the position of the bridge with relation to the cap and upper lip. The

cap A is a thick piece of hardwood, flat on the side toward the block C, and having a sloping portion sunk on the outside, as shown, to allow a current of the external air to approach the mouth under the harmonic-bridge, while the pipe is speaking. B is the harmonic-bridge, a quadrangular bar of hardwood, notched at either end, E, E′, to allow its central portion to approach somewhat nearer the mouth than the thickness of the pipe-front would otherwise permit. The upper inner edge of the bridge is rounded to a quarter circle along its entire length from E to E′, while the lower edge is only rounded from each end a certain distance toward the center, where the roundings curve out, leaving the square-edged portion F, Diagram 3. The shape and position of this bridge are matters of considerable nicety, as they affect the quality and promptness of the tone. This we have tested by pipes copied for the purpose. The block C is sunk in the sloping manner shown, having a sharp edge where the wind-way is cut from it. No nicking is used on either cap or block; and the under lip is flush with the top of the cap. The height of the mouth is a little under one-third its width; and its upper lip is filed almost to a sharp edge. The dimensions of the three C pipes of the stop are as follows:

EDMUND SCHULZE'S SCALE OF VIOLONBASS, 16 FT.

PIPE.	WIDTH.	DEPTH.	HEIGHT OF MOUTH.
CCC. 16 ft.	$5\frac{1}{2}$ inches.	$5\frac{1}{2}$ inches.	$1\frac{7}{10}$ inches.
CC. 8 ft.	$3\frac{3}{8}$ "	$3\frac{3}{8}$ "	1 inch.
C. 4 ft.	2 "	2 "	$\frac{3}{5}$ "

This is a stop that English and American organ builders should strive to imitate, for the value of its voice in the Pedal Organ cannot be overrated. The effect of the stop in the Hindley Organ is remarkably fine, and once heard can never be forgotten by the cultivated ear. Played in a semi-staccato manner, or with a light, sliding motion of the foot on the keys, its imitation of the Double Bass of the orchestra is more striking than that of any other organ stop of the class known to us.

VIOLA.—In the Hindley Organ there is a VIOLA, 8 FT., constructed, in all essentials, similar to the stop just considered, except that its pipes are of different scale and deeper than wide. The dimensions of the CC (8 ft.) pipe are $2\frac{5}{8}$ inches in width by $3\frac{5}{8}$ inches in depth; and its mouth is $\frac{13}{16}$ inch in height: otherwise, the fittings and shaping of the mouth are in the relative proportions given in the illustration, Fig. CCLXXXI. The stop is placed in the Choir Organ on a wind of about 2 inches pressure, and it is remarkably effective in tonal character.

The form of the harmonic-bridge met with in the two stops of the Hindley Organ, above described, appears to have been specially contrived by Schulze, for we have not found it in the works of any other organ builder. He did not confine himself to it, however, for in a fine string-toned stop, of 16 ft. pitch, in the pedal department of the Armley Organ, we find an entirely new form of harmonic-bridge. This is shown in the accompanying illustration, Fig. CCLXXXII. This bridge presents an acute-angled edge toward the lower lip of the mouth throughout

its width. All other details of the lower part of the pipe are clearly shown. Various other forms of harmonic-bridges are used by different organ builders, but they are, judging by tonal results, in no way an improvement on those used by Schulze.

VIOLONE.—In the Pedal department of the Organ in the Parish Church, Doncaster, there is a VIOLONE, 16 FT., made by Schulze on an entirely different system from that followed by him in the VIOLONBASS of the Hindley instrument. Its tone is full, rich, and imitative; but it is somewhat slow of speech, like a great many German stops of the string-tone class. A Diagonal View and Longitudinal Section of the lower portion of the CCC pipe are given in the accompanying illustration, Fig. CCLXXXIII. This pipe measures internally 6⅝ inches square, and its mouth is about 1⅝ inches in height. The peculiarity of the construction of the sound-producing portion of this pipe lies chiefly in the hopper-shaped appendage

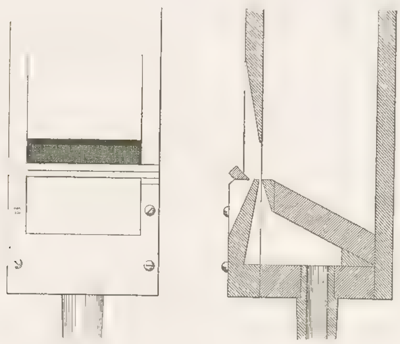


FIG. CCLXXXII.

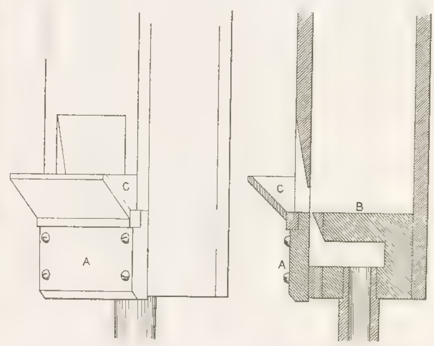


FIG. CCLXXXIII.

to the mouth, C. This rests on the beard of the cap A, while its ends form projecting ears to the mouth. The block B is level on the top and flush with the cap, as shown, having the wind-way cut from it. The cap A is flat on the wind side, as common in pipes with German mouths. All the proportions of the several parts are correctly given in the Longitudinal Section from measurements taken from the pipe itself. The distance across the cap, from the wind-way to the start of the inclined front of the hopper is 1¼ inches; and the inner inclined face of the front and the projection of the hopper both measure 3 inches. In the absence of ocular demonstration, it is extremely difficult to form any conception of the action of the external air on the wind-sheet at the mouth, as it is drawn down the sloping face of the hopper, to fill the partial vacuum caused by the upward rush of the organ-wind from the wind-way. While the action of the external air on the wind-sheet must be similar, to judge from the similarity of tone produced, its mode of approaching the wind-sheet is essentially different from that which obtains where the sloping cap and the harmonic-bridge are used, as in the

VIOLONBASS of the Hindley Organ. In the one case it rushes downward obliquely, and in the other case it is drawn upward obliquely, toward the mouth.

We may now leave the above representative German methods of producing imitative string-tone in wood pipes, and enter on the brief consideration of those which appear to be due to French ingenuity. Both the harmonic-bridge and the acoustical-hopper disappear, and a sloping or curved plate of metal, called the *frein harmonique*, takes their place at the mouth of the pipe. The *frein* (literally a *bridle* or *curb*) is most effective when applied to small-scaled metal pipes*; but, in certain forms, it has proved very effective in connection with small-scaled wood pipes. The *frein harmonique* was invented and patented by Gavioli, of Paris. Owing to the trouble attending its adjustment, and the fact that the harmonic-bridge produces the same effect on the tones of both metal and wood pipes, the *frein* seems to have been seldom used.

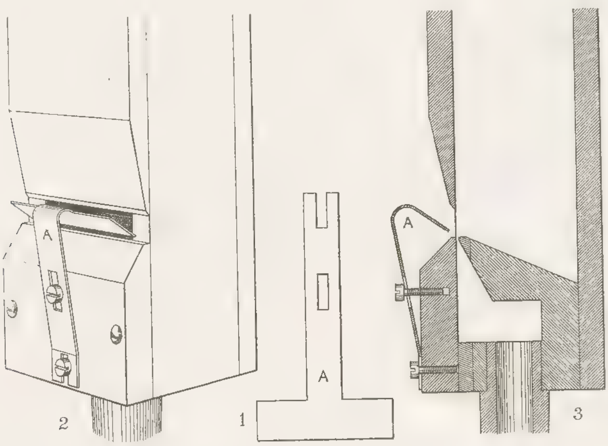


FIG. CCLXXXIV.

VIOLIN.—In the accompanying illustration, Fig. CCLXXXIV., are diagrams showing the construction of the lower part of an open wood pipe, the tone of which is strongly imitative of the corresponding note of the Violin. The drawings are taken from a 4 ft. pipe, the scale of which is 1¾ inch square, with a mouth ⅜ inch in height. To admit the use of the *frein harmonique*, the front of the pipe is sloped across its entire width in forming the upper lip of the mouth; and for the same purpose the upper part of the cap is splayed to almost a sharp edge. This treatment brings the mouth, externally, to resemble the mouth of a metal pipe without ears. The *frein harmonique* is a plate of thin brass, cut to the form

* The first stop having the *frein harmonique* (system Gavioli, on its pipes introduced in an English Organ was the VIOLA D'AMORE, 8 FT., made by Henri Zimmermann, of Paris, for the author's Chamber Organ in the year 1876.

shown at A, in Diagram 1, and slotted for the adjusting screws. This plate is bent into the shape indicated in the other Diagrams, and screwed to the face of the cap, as shown. The slots permit the *frein* to be raised or lowered, and the upper screw adjusts its proper distance from the wind-way. The angle at which the plate approaches the mouth is important, and this must be adjusted by bending the shank. All the three adjustments must be exactly right before the pipe will yield the true imitative tone. The block is slanted downward and has the wind-way cut from it, leaving a sharp under lip; the cap is straight on its inner surface, and no nicking is used on either block or cap. The pipes should be made of straight-grained spruce, with pear-tree or maple fronts and caps; and the blocks must be fronted with the same hardwood. Much depends on the sharpness and accuracy of all the edges touched by the wind-sheet. The under lip and inside

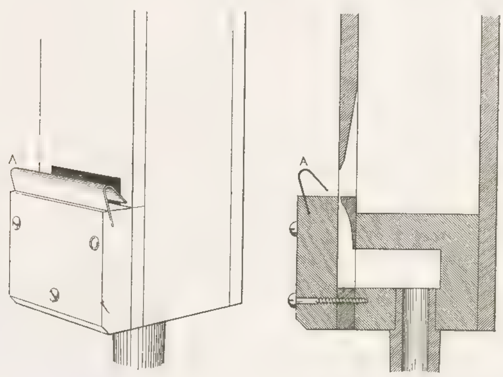


FIG. CCLXXXV.

edge of the cap must be perfectly smooth, and polished with black-lead. The pipes throughout the compass must be made with the greatest accuracy and care; but they amply repay the time and trouble expended on them by the beauty of their tones. This VIOLIN is most satisfactory when voiced on wind of about 3½ inches, but a higher pressure may be used when a very cutting tone is desired.

VIOLONCELLO.—An 8 ft. open stop, producing a string-tone imitative of that of the orchestral Violoncello. It would be impossible, in our opinion, to adopt a better model for a wood stop of this class than that furnished by the fine VIOLONBASS, 16 FT., in the Hindley Organ, already described and illustrated (Fig. CCLXXXI.). It would be desirable to reduce the scale slightly, making the CC pipe 3 inches square internal measurement, instead of 3⅜ inches square as in the case of the 8 ft. pipe of the VIOLONBASS.

A VIOLONCELLO, 8 FT., of delicate and imitative character is made with pipes having inverted mouths and a modified form of the *frein harmonique*, as shown in Fig. CCLXXXV. The drawings are taken from the CC pipe, made for us by

Messrs. Peter Conacher & Co., of Huddersfield, Yorkshire. The scale of the pipe is 2 ⅞ inches in width by 3 ¾ inches in depth, and the height of mouth is ⅞ inch. The block is sunk ½ inch below the mouth; the under lip is sharp and has no nicking; the cap is straight on the inside and has no nicking; the upper lip is cut to almost a sharp edge; and the *frein harmonique* is a stout plate of hard metal held firmly in a saw-cut in the upper end of the cap. The shape and correct position of the *frein harmonique* is given at A. The pipe is made of white pine $\frac{9}{16}$ inch thick, with the mouth and cap of black walnut; it has a slot cut in its upper end, 4 inches long by 1 ⅛ inches, placed 4 inches from the top. The pipe is tuned by means of a piece of wood sliding over a portion of the slot. The hole in the foot is only ½ inch, but that is ample to supply the pipe. The tone produced is like the corresponding note on the Violoncello, softly bowed. The softness of the tone and the absence of a pronounced rasping and cutting quality are apparently due to the manner in which the *frein harmonique* is attached to the cap, preventing a free rush of external air from below the edges of the *frein*. In this respect the treatment just described is unique so far as our knowledge extends.

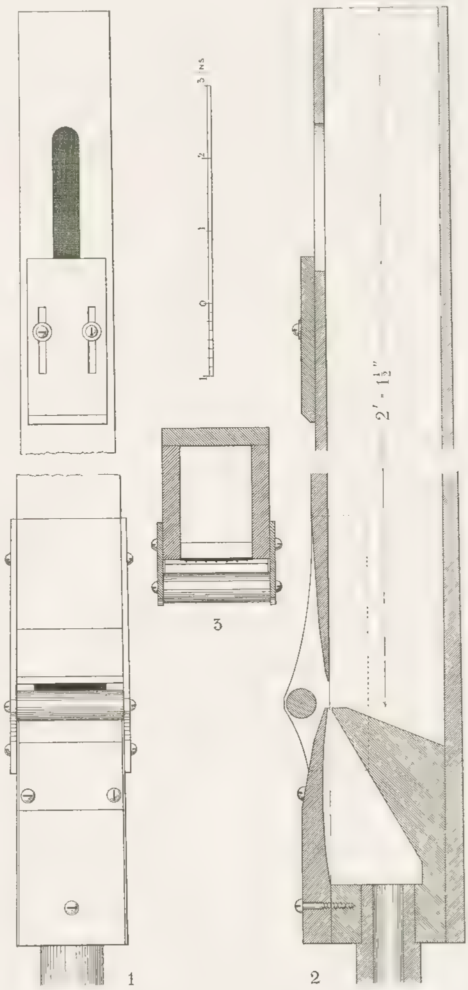


Fig. CCLXXXVI.

Probably the most successful Violoncello, 8 ft., constructed by an English organ builder, is that invented by Mr. John W. Whiteley. A fine example of this stop appears in the Solo division of the Concert-room Organ in the Polytechnic Institute, Battersea,

London. In the construction and treatment of the pipes of this valuable stop some novel features obtain, as will be seen from the drawings and particulars here given—features which, in our opinion, point the way to further developments of an important character. In the accompanying illustration, Fig. CCLXXXVI., is shown part of the middle c^1 pipe of this stop, the scale of which is 1 inch in width by $1\frac{9}{16}$ inches in depth. It will be observed from the illustration that, while the internal dimensions are the same throughout the length of the pipe, the wood, of which it is formed, is evenly reduced in thickness toward the top, being $\frac{1}{4}$ inch at the block and only about $\frac{1}{8}$ inch thick at the open end. The result of this unusual treatment goes to prove that the thickness of the wood used in pipe-making exercises an influence on the tone produced; and this very important factor in pipe formation should not be overlooked. The formation of the mouth and all its associated parts deserves careful study. The slopings of the upper lip are carried entirely across the front in a manner similar to that shown in the VIOLIN pipe, Fig. CCLXXXIV. A similar treatment obtains in the external slopings of the cap, as distinctly shown. The mouth is cut up one-third of its width, and its upper lip is reduced to a fine edge. The lower lip on the block is also sharp, and has no nicking. The cap is slightly hollowed on its inside, also to a somewhat sharp edge, in which a slightly curved wind-way is cut, and finished with seven small nicks, as shown in the Transverse Section through the mouth, Diagram 3. A special peculiarity obtains in the manner in which the cylindrical harmonic-bridge is supported in front of the mouth. This bridge, instead of being simply the length of the mouth, and being attached to small ears, either formed from the wood of the pipe-front or the cap, is carried across the entire width of the pipe, and is supported by two thick spotted-metal plates, which are screwed to the sides of the pipe. The front edges of these plates are sloped away from the bridge so as to free the wind in the neighborhood of the mouth: indeed the entire construction of the mouth portion of the pipe insures perfect freedom to the under stream of air which is generated by the rushing wind-sheet of the mouth. This is essential to the production of the compound tone which so closely imitates that of the orchestral Violoncello. In the larger pipes the harmonic-bridges are made of hardwood, while in the small pipes they are made of aluminium tubing, held in position by points punched inward in the metal side-plates.

In the Organ in the Battersea Polytechnic — the instrument for which this VIOLONCELLO was devised and constructed in 1899 — the stop is carried down to CCC (16 ft.), so as to be available in the pedal department under the name of CONTRA-BASS. From the measurements given of the middle c^1 pipe the scale of the entire stop can easily be developed, preferably on the ratio 1 : 2·66. All the pipes have to be considerably longer than the normal speaking lengths, to allow them to be slotted in the manner shown in Fig. CCLXXXVI.

GEIGENPRINCIPAL.—We have been favored with particulars of a fine string-toned stop constructed by Mr. Thomas Pendlebury, Organ Builder, of Leigh, Lancashire,—an artist in wood-pipe formation and voicing, whose labors in this fertile field deserve special recognition, notably at the present time, when the organ-building world is very generally neglecting wood pipe-work, and correspond-

ingly sacrificing tonal variety and beauty. In the accompanying illustration, Fig. CCLXXXVII., are given a Front View and Longitudinal Section of the lower portion of the CC pipe of Mr. Pendlebury's Geigenprincipal, 8 ft., carefully reproduced from the full-size drawing which has been kindly furnished us. The most notable features are the special forms of the block, cap, and harmonic-bridge, all of which contribute toward the production of the characteristic voice of the pipe. Speaking of his stop, Mr. Pendlebury remarks: "When fully blown, and when given ample speaking room, and played alone in full chords, it delivers as much tone and is quite as brilliant as any full Swell of five or six stops known to me,

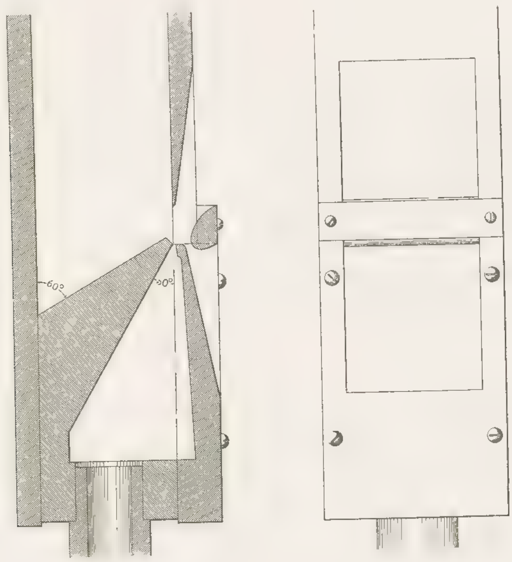


Fig. CCLXXXVII.

Schulze's work excepted. The absence of what is commonly known as 'interference' in this description of stop is very remarkable; or, I may say, the enormous amount of 'interference' which metal pipes have, is only properly realized when compared with a stop of this class. When the stop is tried in single notes or as a solo, it does not strike the ear as being of extraordinary power; but when chords are played (especially in the lower octaves) it is remarkable how each individual note adds to the others. The stop is a full organ division in itself." Mr. Pendlebury further states: "The blocks of the pipes are of solid hardwood (usually hornbeam). The tops of the blocks are sunk at the angle of 30° from the horizontal, and their fronts in the throats are inclined inward at the angle of 30° from the vertical. Their edges adjoining the wind-ways are beveled in the same manner

as are metal languids. The nicking is deep and is carried a considerable distance down the slanting surfaces of the blocks." The above particulars will be clearly understood, assisted by Fig. CCLXXXVII. The scale of the stop is indicated by the following dimensions:

THOMAS PENDLEBURY'S SCALE OF GEIGENPRINCIPAL, 8 FT.

PIPE.		WIDTH & DEPTH.	HEIGHT OF MOUTH.	FOOT-HOLE.
CC.	8 ft.	3 inches.	$\frac{3}{4}$ inch.	$1\frac{1}{8}$ inches.
C.	4 ft.	$1\frac{13}{16}$ "	$\frac{7}{16}$ "	$\frac{3}{4}$ inch.
c^1.	2 ft.	$1\frac{3}{16}$ "	$\frac{5}{16}$ "	$\frac{1}{2}$ "
c^2.	1 ft.	$\frac{3}{4}$ inch.	$\frac{3}{16}$ "	$\frac{3}{8}$ "
c^3.	$\frac{1}{2}$ ft.	$\frac{1}{2}$ "	$\frac{1}{8}$ "	$\frac{1}{4}$ "

Geigenoctave.—This is a stop, of 4 ft. pitch, constructed in all essentials similarly to the Geigenprincipal, 8 ft. The following dimensions indicate the scale of the stop:

THOMAS PENDLEBURY'S SCALE OF GEIGENOCTAVE, 4 FT.

PIPE.		WIDTH.	DEPTH.	HEIGHT OF MOUTH.	FOOT-HOLE.
CC.	4 ft.	$1\frac{5}{8}$ inches.	$1\frac{1}{4}$ inches.	$\frac{3}{8}$ inch.	$\frac{1}{2}$ inch.
C.	2 ft.	$1\frac{1}{8}$ "	$\frac{7}{8}$ inch.	$\frac{1}{4}$ "	$\frac{3}{8}$ "
c^1.	1 ft.	$\frac{11}{16}$ inch.	$\frac{11}{16}$ "	$\frac{3}{16}$ "	$\frac{1}{4}$ "
c^2.	$\frac{1}{2}$ ft.	$\frac{7}{16}$ "	$\frac{7}{16}$ "	$\frac{1}{8}$ "	$\frac{3}{16}$ "
c^3.	$\frac{1}{4}$ ft.	$\frac{1}{4}$ "	$\frac{1}{4}$ "	$\frac{3}{32}$ "	$\frac{1}{8}$ "

A Violin, 8 ft., of most effective character, is constructed by Mr. Thomas Pendlebury. Its pipes are formed in all essentials similarly to those of his fine Geigenprincipal, 8 ft., already described and illustrated in Fig. CCLXXXVII. The pipes forming the stop are square and of much smaller scale than those of the Geigenprincipal, as will be seen from the following dimensions:

THOMAS PENDLEBURY'S SCALE OF VIOLIN, 8 FT.

PIPE.		WIDTH & DEPTH.	HEIGHT OF MOUTH.	FOOT-HOLE.
CC.	8 ft.	2 inches.	$\frac{5}{8}$ inch.	$\frac{7}{8}$ inch.
C.	4 ft.	$1\frac{3}{16}$ "	$\frac{3}{8}$ "	$\frac{5}{8}$ "
c^1.	2 ft.	$\frac{3}{4}$ inch.	$\frac{1}{4}$ "	$\frac{3}{8}$ "
c^2.	1 ft.	$\frac{1}{2}$ "	$\frac{3}{16}$ "	$\frac{1}{4}$ "
c^3.	$\frac{1}{2}$ ft.	$\frac{3}{8}$ "	$\frac{1}{8}$ "	$\frac{1}{8}$ "

It will be seen that this is a compound scale. From CC to C it is practically in the ratio $1 : \sqrt{8}$; while from C to the top note it is approximately in the ratio $1 : 2 \cdot 3$, halving on the twentieth note. The pipes are fitted with harmonic-bridges (of the peculiar shape shown in Fig. CCLXXXVII.) from CC to c^3. In speaking of

this stop, Mr. Pendlebury remarks: "I have obtained good results from very much smaller scales; but, as I have found the VIOLIN of the scale given to produce tones as keen as those of the true Violin and Violoncello, I do not favor tones of less body produced from small scales." Mr. Pendlebury very properly recommends the languid, inside of cap, and the entire throat of every pipe yielding string-tone to be thrice coated with shellac varnish, and to have both its wind-way and harmonic-bridge black-leaded and polished. The latter treatment is particularly desirable in the pipes of the treble octaves.

WOOD PIPES OF SPECIAL TONALITIES.

HARMONICA.—The open wood stop called HARMONICA is of German origin, and numerous fine examples are to be found in Organs constructed by leading German builders. Some idea of the appreciation in which this stop is held may be gathered from the fact that in "Die Theorie und Praxis des Orgelbaues" about two pages are devoted to notes on its construction, while more important stops are passed over in a comparatively brief manner. The HARMONICA, in its true form, is practically ignored by the English, French, and American builders, probably on account of the trouble which attends its voicing, regulating, etc., and the mistaken idea that the same quality of tone can be obtained from pipes of much simpler formation. In the words of Töpfer, the HARMONICA "ist eine Stimme von ätherischem Charakter, welche bei sanften Altargesängen zum Gemüte des stillen Beters spricht."

The scale and proportions of the HARMONICA vary in different examples; and while in the generality of cases its pipes are straight, in others they are slightly tapered. For the stop of 8 ft. pitch, composed of straight, square pipes, Mr. Haas has given the following scale: CC, 66 mm; C, 40 mm; c^1, 24 mm; c^2, 15 mm; and c^3, 9 mm. Some German organ builders use scales which give the pipes of the HARMONICA a greater depth than width. We have an extreme illustration of this in the fine HARMONICA in the Choir division of the Organ in the Church of St. Bartholomew, Armley, where we find the pipes from middle c^1 to the top note nearly twice their width in depth. Schulze seems to have found this extreme proportion favorable to the production of very delicate qualities of tone; for he has adopted it for the characteristic pipes of the ECHO OBOE, 8 FT., in the Echo division of the same Organ, as will be shown later on.

The tone of the HARMONICA, in its best form, is extremely refined in character, being a combination of flute- and string-tone. The mouth and compound cap of the HARMONICA pipe resemble those of the ORCHESTRAL FLUTE, illustrated in Fig. CCLXXVIII. The HARMONICA differs, however, from the imitative, circular-mouthed stops in not being harmonic in any portion of its compass. The form and construction of the mouth and cap are shown in the accompanying illustration, Fig. CCLXXXVIII., which presents a Front View and Section of the middle c^1 pipe of Schulze's stop in the Armley Organ. Here the wedge-piece of the compound cap covers about one-third of the diameter of the circular mouth; but dif-

ferent positions are adopted according to the quality of tone required. The less the mouth is covered, the rounder and softer is the tone: when more than one-third is covered, the tone becomes somewhat cutting and the string-tone more strongly marked. The chief difficulty in connection with the voicing of the HARMONICA obtains in the adjustment of both the parts of the caps with relation to the circular mouths,* so as to obtain a perfectly even intonation throughout the compass. The size of the circular mouth varies according to the strength and quality of tone desired; it should, however, never be less than one-half the internal width of the pipe. In pipes that are narrow and deep, the diameter of the mouth

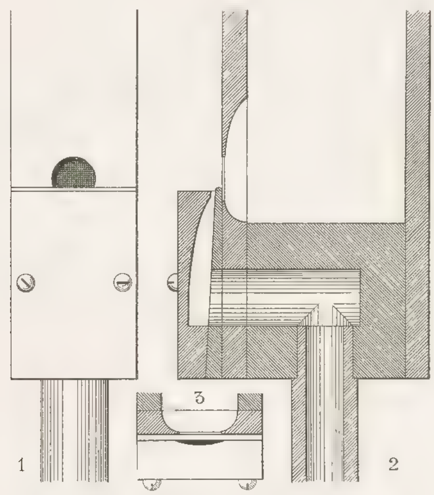


FIG. CCLXXXVIII.

may approach to two-thirds of the internal width. In the construction of the compound caps extreme care must be taken to graduate the thickness of the wedge-piece. For the CC (8 ft.) pipe the rounded end of the wedge-piece which adjoins the mouth should be about $\frac{3}{16}$ inch, and this must diminish gradually until at c^3 it is about the thickness of a calling card. The thickness of the lower end of the wedge-piece will usually range from $\frac{7}{16}$ inch at CC to $\frac{3}{32}$ inch at c^3; but all these

* The dimensions given by Töpfer-Allihn for the outer portion of the cap (Frosch) and the inner wedge-piece (Platte) are of sufficient importance to be given here: "Die Länge der grössten Frösche kann 50 mm betragen und nimmt ab bis zu 36 bis 40 mm. Die Dicke kann für die grösseren Pfeifen 20 mm und für die kleineren zwischen 3 bis 10 mm betragen. Es versteht sich, dass die vordere Dicke der Platte von den höchsten Tönen bis zum tiefsten gleichmässig zunehmen muss, weil ausserdem die Gleichmässigkeit des Tones darunter leiden würde. Man kann diese Dicke für C_0 8 Fuss 5 mm und für c^3 0,2 mm setzen. Bei diesen Annahmen erhält man die vordere Dicke der Platte für $c^0 = 2{,}2$ mm; für $c^1 = 1$ mm; für $c^2 = 0{,}45$ mm. Die hintere Dicke nimmt von 8 mm bis zu 3 mm ab."—"Die Theorie und Praxis des Orgelbaues," p. 232.

dimensions must be arrived at by experiment, or dictated by experience, just as the exact position of the upper edge of the cap over the lower part of the circular mouth must be determined in the process of voicing. The length of the caps may range from 2¼ inches to 1½ inches; but when the exact inclination or angle of the wedge-piece is determined, its length may be decided according to taste.

The HARMONICABASS (16 ft.), is constructed in the manner above described for the unison stop. The scale, according to Friedrich Haas, gives, for square pipes, the following dimensions: CCC, 109 mm; CC, 67·3 mm; and C, 41 mm.

As the tone of the HARMONICA is extremely delicate, the pipes may be made of thinner wood than is necessary for those which produce powerful sounds. The wood for the CC pipe need not exceed ½ inch finished thickness. The backs and sides should be of clear spruce, such as is used for piano sound-boards; and the fronts should be of maple in the larger, and pear-tree in the smaller pipes. The caps should be of beech.

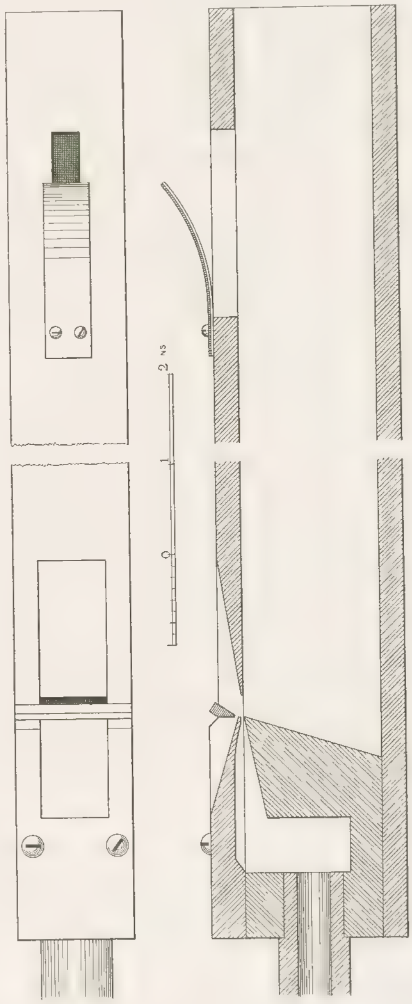


FIG. CCLXXXIX.

ECHO OBOE.—The present Chapter would not be in any sense complete without a description of another of Schulze's remarkable wood stops, named by him ECHO OBOE, doubtless on account of its peculiar tonal quality, which, though difficult to describe, may be classed as a combination of extremely delicate reed- and string-tone. An ECHO OBOE, 8 FT., made by Schulze, is inserted in the Echo division of the Organ in the Church of St. Bartholomew, Armley; and an exact copy, by Messrs. Abbott & Smith, is to be found in the Echo division of the Organ in Leeds Parish Church. In both Organs it speaks on wind of 1½ inches; and its tone is somewhat plaintive in character and exquis-

itely sweet. A more desirable voice for a Chamber Organ it would be difficult to conceive. The accompanying illustration, Fig. CCLXXXIX., gives a Front View and Section of the middle c^1 of the stop in the Armley Organ. It measures internally ¾ inch in width by 1⅛ inches in depth; and has a speaking length of 25 inches, which allows for the slotting. The mouth is one-third its width in height, and is formed in the usual direct manner, having its upper lip straight and reduced to the thickness of an ordinary calling-card. The block is sloped on top and front as shown in the Section, its edge, which forms the lower lip of the mouth, is finished sharp and has no nicking. The cap is slightly hollowed on the inside to admit of the wind-way being formed: this is extremely fine and has nine slightly marked diagonal nicks. Externally the cap is sloped opposite the mouth, so as to leave only about the thickness of $\frac{1}{40}$ inch at the wind-way, as indicated in the Section. A knife-edged harmonic-bridge is fixed at an angle across the mouth, resting on the cap, and leaving an air-slit between it and the adjoining edge of the cap, $\frac{1}{16}$ inch wide. The treatment of all parts of the mouth is extremely delicate, demanding most accurate and careful workmanship. The fronts of the pipes should be of maple or pear-tree, and the blocks and caps of beech. The harmonic-bridges should be formed of boxwood. The upper ends of the pipes are slotted, and tuned by strips of spotted metal, covered with leather to prevent any vibration. This arrangement is shown in the upper diagrams in Fig. CCLXXXIX. The scale of the c^2 pipe is $\frac{7}{16}$ inch in width by ⅞ inch in depth, and its mouth is one-third its width in height. The regulation of the wind supply to the mouths of the pipes in a stop of such extreme delicacy calls for metal-tipped feet, so as to admit of easy and nice manipulation. The foot of the middle c^1 pipe has a hole in its tip of only about ⅛ inch in diameter, while that of the c^2 pipe has a hole of $\frac{1}{16}$ inch. The wood pipes of the Echo Oboe in the Armley Organ commence on tenor C. Below that note the stop is grooved into the Vox Angelica, 8 ft., in the same division of the instrument. It will be observed that the form of the harmonic-bridge and the general treatment of the mouth closely resemble those of the Pedal Violone, 16 ft., in the same Organ, as shown in Fig. CCLXXXII.

Corno Dolce.—The open wood stop to which this name has, apparently with some propriety, been given is another of the creations of Mr. Thomas Pendlebury. The tone of this fine stop is brighter than that of the true Clarabella or Hohlflöte. In the tenor and middle octaves the tone strongly resembles that of the orchestral Horn played softly; and it is this fact that has induced the inventor to name the stop Corno Dolce. In his notes on the stop, Mr. Pendlebury remarks: "In the tenor and middle octaves the tone sounds much more pure in chords than in single notes. It has both body and brilliancy, yet the upper partial tones, present in the compound voice of the pipes, do not stand out in the self-assertive manner peculiar to those which belong to the pungent voice of string-tone pipes."

The peculiar formation of the tone-producing portion of a Corno Dolce pipe is shown in Fig. CCXC., which is a Longitudinal Section of this portion of a middle c^1 pipe. The inverted mouth is cut in the wide side of the pipe, and is kept moderately low; the block is slanted; the cap is beveled internally; and the wind-way is kept very fine. But perhaps the most noteworthy feature of the pipe

is thus mentioned by the inventor: "In forming the throat, a hole as large as the scale will allow is bored from the front right through the back of the pipe. This hole [shown shaded in Fig. CCXC.] is covered at the back of the pipe with very soft leather [indicated at A], left somewhat slack so as to receive the first shock of the wind. This leather diaphragm also helps to neutralize the vibrations of the wind in the throat and foot, which vibrations are of greater detriment to the tone of labial pipes than is generally realized. On touching the diaphragm with the finger while the pipe is speaking the vibrations are distinctly felt." The most favorable wind-pressure for this stop is 3 inches. The following dimensions give the most approved scale of the stop:

PENDLEBURY'S SCALE OF CORNO DOLCE, 8 FT.

PIPE.	WIDTH.	DEPTH.	HEIGHT OF MOUTH.	FOOT-HOLE.
CC. 8 ft.	2 inches.	1 ½ inches.	½ inch.	½ inch.
C. 4 ft.	1⅝ "	1 ½ "	⅜ "	⅜ "
c^1. 2 ft.	1½ "	1 $\frac{3}{16}$ "	⅜ "	¼ "
c^2. 1 ft.	⅞ "	¾ "	¼ "	$\frac{3}{16}$ "
c^3. ½ ft.	⅝ "	⅝ "	$\frac{5}{32}$ "	⅛ "

The pipes of the bass octave are formed similar to those of the GEIGENPRINCIPAL, illustrated in Fig. CCLXXXVII., their mouths being kept low and their wind-ways very fine. The harmonic-bridges are so placed as to produce a reedy rather than a stringy intonation. The pipes of the tenor octave are modified so as to join the bass to the treble tones in an artistic manner. In such delicate treatments Mr. Pendlebury shows his mastery over wood pipe-work. Alluding to the dimensions above given, Mr. Pendlebury makes the following noteworthy remarks: "It will be observed that the scales and the heights of the mouths of the pipes of the tenor octave are nearly the same, with the result that each pipe is slightly different in quality. The beauty of the stop is not in any one particular pipe, but in the *gradual changing* of the tone-color. The beauty of the *crescendo* and *diminuendo* of the Swell, or of the voice or any musical instrument, does not lie in the changing of strength of tone, as is generally thought, but in the changing of quality."

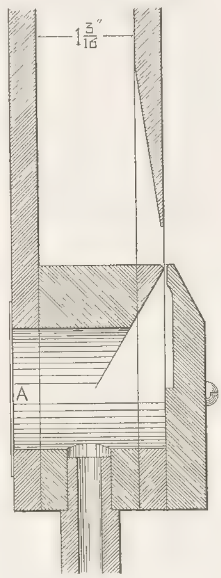


FIG. CCXC.

OBOE.—We have now to describe and illustrate a labial stop of remarkable character, which yields a tone almost identical with that of the orchestral Oboe. This wood stop was recently invented by Mr. W. E. Haskell, an American organ-builder who has paid considerable attention to the subject of tone production.

The drawings given in Fig. CCXCI. clearly show the form and construction of the middle c^1 pipe of this labial OBOE, 8 FT. The body of the pipe measures 7/8 inch square, internally, at its mouth line, and, while its width remains the same, its depth is gradually reduced to $\frac{11}{16}$ inch at its open end, the reduction commencing at twelve inches above the mouth and taking a curved form from that point in the front of the pipe, as indicated in the Section, 1. The block is sunk 3/8 inch below the lower lip of the mouth. The mouth is inverted, and its lower lip is sloped on the inside down to the block level and slightly rounded. The upper lip is filed on the outside so as to produce a sharp edge slightly back from the face of the pipe. All these peculiarities are accurately indicated in the Section. The mouth is a fraction over 1/8 inch in height. The cap is made sufficiently long to extend about 1/8 inch above the upper lip of the mouth, and is cut away and sloped on the outside so as to support the small cylindrical harmonic-bridge in position, as shown in the Section, 1, and Front View, 2. The cap is hollowed on the inside, and is filed so as to produce a small sharp-edged wind-way, just sufficient to admit the passage of a strip of a playing-card. The cap is not nicked. The under lip of the mouth has twenty-seven straight and cleanly-cut nicks, as depicted in Diagram 3, which shows the mouth and lower part of the pipe with the cap removed. The illustrations are so accurately drawn to scale that further description of the sound-producing portion of the pipe is unnecessary. The pipe is tuned in the usual way by a metal shade at top. The stop is voiced on wind of 3½ inches, the pipes requiring a very small supply. As the orchestral Oboe does not descend below B♭, the stop under review when carried down to CC should certainly be labeled OBOE & FAGOTTO, 8 FT.

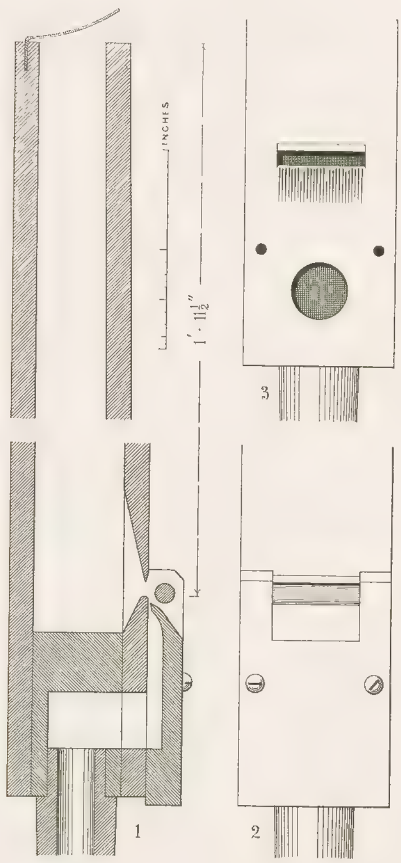


FIG. CCXCI.

SAXOPHONE.—We may conclude this special branch of our subject with a description of the form and construction of another remarkable imitative wood

stop, invented by Mr. W. E. Haskell, and first introduced in the Organ built by Mr. C. S. Haskell for the Church of the Holy Trinity, Philadelphia, Pa., in 1897.

This fine stop is of 8 ft. pitch, and extends throughout the manual compass. Its scale is as follows: CC pipe, $3\frac{5}{16}$ inches in width by $4\frac{3}{16}$ inches in depth; C pipe, 2 inches in width by $2\frac{9}{16}$ inches in depth; c^1 pipe, $1\frac{3}{16}$ inches in width by $1\frac{17}{32}$ inches in depth; and c^2 pipe, ¾ inch in width by $\frac{31}{32}$ inch in depth. The accompanying illustration, Fig. CCXCII., which gives a Front View and Section of the sound-producing portion of the middle c^1 pipe, shows a formation almost identical with that in the labial Oboe previously illustrated. The block is sunk ¾ inch below the lower lip. The mouth is inverted, and its lower lip is sloped on the inside of the pipe and slightly rounded. The upper lip is filed to a very thin edge in the same manner as that of the Oboe pipe. The cap and the large cylindrical harmonic-bridge are so clearly shown that it is unnecessary to describe them. Both the face of the lower lip and the opposite edge of the cap are closely and sharply nicked. The mouth is a small fraction over two-sevenths its width in height. The body of the pipe is of the same dimensions throughout its length, and it is unslotted, being tuned by means of a metal shade at top in the usual manner.

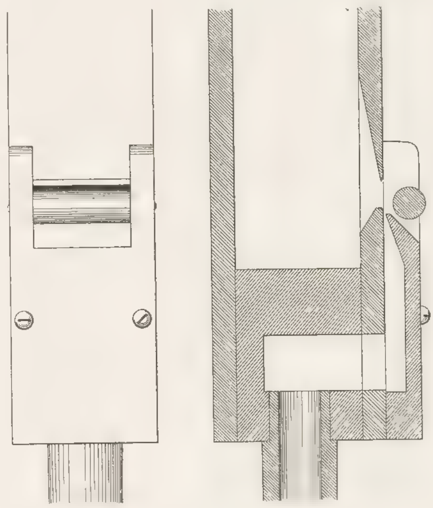


Fig. CCXCII.

Voiced on wind of about 3½ inches, this stop yields a tone exactly imitative of that of the orchestral Saxophones, described by Berlioz as possessing "most rare and precious qualities. Soft and penetrating in the higher part, full and rich in the lower part, their medium has something profoundly expressive. It is, in short, a quality of tone *sui generis*, presenting vague analogies with the sounds of the Violoncello, of the Clarinet, and Corno Inglese, and invested with a brazen tinge which imparts a quite peculiar accent." It seems too much to expect that so peculiar and complex a tone could be produced from wood pipes; but we have satisfied our mind on the subject by testing the stop, as inserted in the Organ above-mentioned, by a direct comparison with the orchestral Saxophone, performed upon in the Organ immediately alongside the stop. While the imitation was practically perfect, in certain parts of its compass the Saxophone of the Organ was, if anything, more pleasing than the corresponding tones of the orchestral instrument. The stop is a notable achievement, and great credit is due to its inventor. It certainly goes

to prove that much can still be done through the agency of wood pipes to enrich the imitative voices of the Organ.

THE FEET OF WOOD PIPES.

The feet of wood pipes, or those portions which immediately rest on the wind-chest, and through which the compressed air is conveyed from the wind-chest to the throats and wind-ways of the pipes, call for some special consideration, especially with reference to the means adopted in connection with them to control or regulate the supply of air to the pipes. The feet of wood pipes are usually formed entirely of wood; but recently essays have been made to furnish them with metal tips or "toes," so as to render the regulation of the wind supply as easy and permanent in them as it is in the feet of metal pipes.

Fig. CCXCIII.

The ordinary pipe-foot is a piece of hardwood about 7 inches in length over all, bored throughout, and turned externally with a slight taper, having a sloped end where it rests in the perforation in the wind-chest, and a socket-piece at the other end where it is fixed into the block of the pipe. This form of foot is shown in Elevation and Longitudinal Section, in Fig. CCXCIII. The external taper is for the purpose of allowing the foot to be easily placed in and removed from the rack-board, and to find a firm support therein when in proper position on the perforation of the wind-chest. It is only necessary for the bore of the foot to be smooth and free from loose pieces which might be blown into the narrow wind-way of the pipe and impair its speech. This may be done by rubbing the bore with sand-paper, glued around a rod of wood. For really good work, the bore, as well as the exterior of the foot, should receive a coat of shellac varnish. This protects the foot from the action of damp air and keeps it clean inside.

The pipe-foot, as above described, is inserted into, and securely glued to, the lower portion of the block of the pipe, as shown in the illustrations previously given in the present Chapter. It accordingly conducts the compressed air from the perforation in the wind-chest directly into the throat of the pipe. In small pipes the feet are invariably inserted in the center of the blocks; but in the case of large pipes, which are with some difficulty planted on the wind-chest, over or in the immediate neighborhood of their wind, their feet may be inserted in any convenient position in the blocks, so long as their throats are communicated with in a proper manner.

Several sizes of bores are required in a complete set of wooden pipe-feet; and these are graduated in groups, for it is not necessary for them to be graduated

regularly, as in the case of metal pipes. Groups of six are convenient, as two groups are given to each octave; but other arrangements are frequently adopted according to the judgment of different organ builders. The following table shows the full diameters of the bores of pipe-feet for ordinary use in stops of 8 ft. pitch.

PIPES.	DIAMETER OF BORE.	PIPES.	DIAMETER OF BORE.
CC to FF.	$1\frac{1}{2}$ inches.	f♯[1] to b[1].	$\frac{5}{8}$ inch.
FF♯ to BB.	$1\frac{1}{4}$ "	c[2] to f[2].	$\frac{1}{2}$ "
C to F.	1 inch.	f♯[2] to b[2].	$\frac{7}{16}$ "
F♯ to B.	$\frac{7}{8}$ "	c[3] to f[3].	$\frac{3}{8}$ "
c[1] to f[1].	$\frac{3}{4}$ "	f♯[3] to c[4].	$\frac{5}{16}$ "

For small-scale and softly-voiced wood stops, feet with smaller bores than are above given may be used, for it is only necessary to furnish wind passages of sufficient size to carry the requisite supply of wind to the pipes, with as little loss of force from friction and expansion as possible. The exact supply of wind is regulated at the tips of the feet, as will be explained later on.

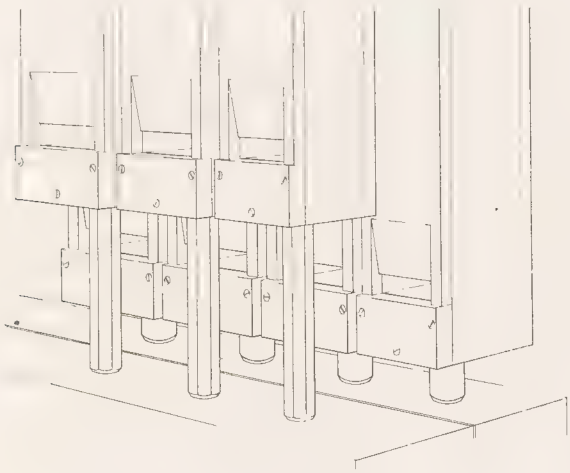


FIG. CCXCIV.

We have mentioned 7 inches as the ordinary and convenient length for pipe-feet, but much longer feet are frequently required when large pipes are planted so closely together that the bottoms of some have to be elevated above the mouths of others so as to give them the necessary room to speak. When large pipes, such as those of the Pedal Organ, are planted closely together against a wall, it is necessary to elevate the front pipes on long feet above the mouths of the back ones, in a manner similar to that indicated in the accompanying illustration, Fig.

CCXCIV. By this arrangement economy of standing-room is secured, and the back row of pipes has ample speaking-room, the tall feet of the front row offering no impediment.

The feet of the very large wood pipes of the Pedal Organ, such as those forming the lower octave of the DOUBLE PRINCIPAL, 32 FT., are frequently built up square, and are simply short wind-trunks, securely fixed in the bottom boards of the pipes, and let into square openings in the wind-chests.

When wood pipes are employed as decorative features in the external design of an Organ, their feet may be turned in some graceful, ornamental form and suitably decorated, adding much to the general appearance of the displayed pipes.

REGULATING THE WIND SUPPLY OF WOOD PIPES.

The correct regulation of the wind supply to pipes of all classes is a matter of paramount importance; for not only do the proper tones of the individual pipes of a stop depend upon the exact amount of wind supplied to them, but the general beauty of the entire stop depends on perfect regularity of strength and uniform quality of tone, largely due to a correctly-graduated supply of wind.

Notwithstanding the paramount importance of the careful and accurate regulation of every stop in an Organ, it is rare, indeed, to find an instrument which can be pronounced entirely satisfactory in this respect. Two things are requisite for proper regulation; namely, a good musical ear, educated to detect the slightest irregularity in strength of tone and difference in tonal coloring; and an expenditure of considerable time and patience. Now, these are things not invariably found flourishing in organ builders' establishments. Time is money, and a great deal may be expended in the artistic regulation of an instrument of many stops. We know this from experience; and we also know the great value of artistic regulation. A badly-regulated Organ is an abomination to the sensitive musical ear; and as Organs are seldom in perfect tune the faults in regulation become more prominent and objectionable.

The regulating of wood stops that are formed of the same class of pipes throughout their compass is not a matter requiring any exceptional skill; but considerably more difficulty obtains in the perfect regulating of such stops as are formed partly of open pipes and partly of covered ones; or which have harmonic and non-harmonic pipes in different parts of their compass. Much can be done by skilful regulation to cover the breaks which occur where the different kinds of pipes meet.

The apportionment of wind to pipes belonging to the ordinary manual wood stops is regulated at the tips of their feet by different methods, the most common, as well as the most imperfect, of which is that of plugging by pieces of wood, pressed in, in any direction, across their bores, until the necessary reduction of the wind supply has been reached. To secure perfect regulation by this unworkmanlike method is next to an impossibility; and its results are not permanent, for the pieces of wood so inserted are liable to swell or shrink under the action of moist or dry air, seriously disturbing the regulation.

When wood is used for regulating the wind supply, the following method should be adopted: Small slices of some close-grained hardwood, such as beech or pear-tree, about 3/8 inch thick, are cross-cut from the end of a rod, and after being neatly fitted are glued, or tightly driven, into the tips of the pipe-feet. A hole is bored in the center of each plug through which the wind is to enter the foot, care being taken to bore smaller holes than will ultimately be necessary. Then, by means of a tapered bit or reamer the holes are gradually enlarged until the requisite strength of tone is reached. This process is conducted in the course of voicing, and when the pipes are on the voicing-machine; but as it is not the final regulation, which in all cases should be done when the Organ is erected in permanent form, it is advisable to leave the strength of tone a little under what it will ultimately be, so that the final regulating may be easily accomplished without having to do more than very slightly enlarge the holes in the feet of the pipes. The holes should be slightly countersunk with a sharp rose-bit to prevent the wind making a hissing noise as it enters the pipe-feet. In Fig. CCXCV. are

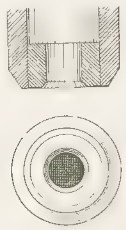


Fig. CCXCV.

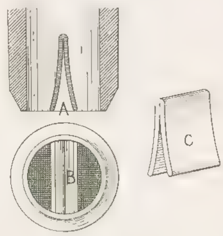


Fig. CCXCVI.

given the Section and Exterior View of the tip of a pipe-foot, showing the treatment just described. When carefully conducted, this mode of regulating is satisfactory; but inasmuch as the holes in the plugs are not capable of being reduced as well as enlarged, it is attended with a difficulty which too often induces the organ-builder to pass pipes that are not regulated as they ought to be. When the holes are made too large the fault can only be remedied by inserting new plugs, or by inserting thin slips of wood or metal in the holes.

The use of regulators formed of pipe-metal is to be highly recommended; for such regulators are in every way preferable to the best made of wood, simply because they are flexible, allowing the wind supply to be increased or diminished with the greatest ease, and remaining, when adjusted, unaffected by damp or dry air. The simplest and most efficient form of regulator applied to the ordinary wood pipe-foot is that which is shown in the accompanying illustration, Fig. CCXCVI. The regulator consists simply of a folded strip of spotted metal, cut so as to fit tightly across the bore of the pipe-foot, as indicated at A in the Section and at B in the Exterior View. The form of the metal regulator is shown at C. It can be readily understood that with this extremely simple appliance the accurate regulating of a pipe is a matter of great ease. This is accomplished by simply

opening or closing the ends of the folded metal with any convenient tool—reducing or increasing the spaces for the passage of the wind.

The difficulty attending the regulation of the delicate-toned wood pipes, which require a very small supply of wind, by the common methods, has induced organ builders to seek the means of imparting to their feet the flexibility of the feet of metal pipes. This has been done by fixing to the wood feet tips of pipe-metal, made in the same manner as the tips of metal pipes. We have before us as we write pipes made by Abbott and Smith, of Leeds, in imitation of the Echo Oboe pipes in Schulze's Organ in Armley Church, the feet of which have tips formed of ordinary sheet pipe-metal, rolled up, and soldered in the usual manner.

Wooden pipe-feet have been recently introduced on which metal tips are cast. A section of one of these compound pipe-feet is given in Fig. CCXCVII., which clearly shows the manner in which the metal toe or tip B is secured to the wood foot A. After the wooden feet are bored and turned to the several standard sizes, they are placed in the required position in the metal moulds and cored, and the tips are cast upon them.* The chief, and perhaps the only objection that can be advanced against pipe-feet so made is the tendency of their wooden portions to shrink and become loose in the metal tips. This imperfection can be guarded against by using perfectly-seasoned and dry hardwood, which, under all general conditions, is in its nature little given to contraction and expansion. There is, however, another matter which will interfere with the common use of these compound feet; namely, their expense; but as there are comparatively few wood pipes in an Organ, and as much time is saved in regulating them, organ builders who desire to produce really good work should not hesitate to use them, especially for the more delicate-toned and sensitive stops.

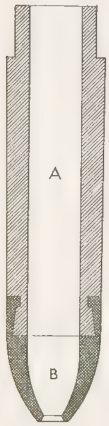


Fig. CCXCVII.

In the case of the large feet, either round or square, belonging to the pipes of Pedal Organ stops of 32 ft. pitch, or the lower octave of similar wood stops of 16 ft. pitch, a means of regulation different from those above described has to be adopted. The most convenient appliances are those illustrated in Fig. CCXCVIII. The appliance shown in the Sections A and B consists of a turned regulator of wood fitting tightly into holes bored transversely through the pipe-foot, and cut away to a thin plate where

* In the manufacturers' circular are the following remarks: "It will be apparent, of course, that when the hot metal is cast about the bulging or locking tenon in this manner, practically all the moisture in the tenon will be expelled, and it will contract considerably, the metal at the same time also contracting upon it, will form a ferrule or toe of less size than would be required for the normal size of the tenon. The tenon after the cooling of the metal will have a tendency to resume its normal condition.

"This will result, of course, in a short time, in the absorption of the wood at this point of the normal amount of moisture, and hence the wood will swell within the metal toe and the two parts will be connected by an extremely tight and locking fit.

"The tip, as before stated, is attached to the wood body of the pipe-foot directly by casting said toe around the locking or bulging tenon. With this combined wood and metal pipe-foot, wood plugs are discarded, and the annoyance of split toes avoided; and the same method and convenience of regulation is obtained for wood pipes as for metal."—Circular of the Mansfield Organ Pipe Works.

it passes across the wind-way of the foot, and, also at one end to enable it to be turned at pleasure in the process of regulating. This is a very convenient appliance for pipe-feet of medium size, which are square in form. At A is shown the manner in which, by simply turning the regulator, the wind supply can be increased or diminished. The arrows indicate the direction of the wind as it passes the regulator. The Sections C and D show a different form of valve regulator. It consists of a small turned spindle of wood which passes across the bore of the pipe-foot, through holes bored opposite each other in the foot, and which has a tinned iron or zinc disc or plate, fixed in a saw-cut, and fitted to the bore of the foot. The drawings clearly show the way in which this simple appliance controls the wind supply. This regulator is well adapted for large cylindrical or square pipe-feet. With both the regulators just described, no pipe has to be moved from its wind-chest in the process of regulating.

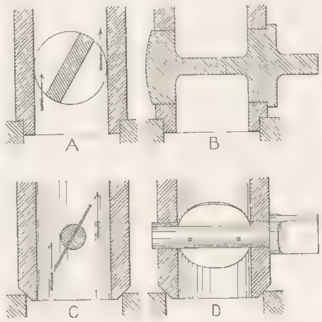


Fig. CCXCVIII.

THE TUNING APPLIANCES OF WOOD PIPES.

Several methods of tuning have been devised for wood pipes, and these will be briefly considered here. Different classes of pipes require special tuning appliances adapted to their tonal character, which, on one hand, are conducive to the production of certain qualities of tone, and which, on the other hand, exercise no appreciable effect on their normal intonation, beyond the slight alteration in pitch incident to the process of tuning.

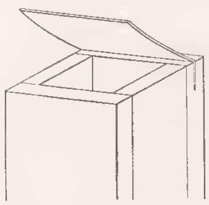


Fig. CCXCIX.

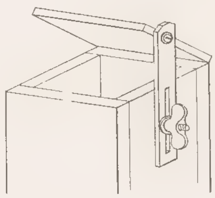


Fig. CCC.

For open flute-toned pipes of 4 ft. speaking length, and for all similar pipes of lesser size, the most convenient tuning appliance consists of a spotted-metal plate or shade, inserted into a saw-cut in the back of the pipe, and bent over so as to overhang, to a greater or lesser degree, the open end or top of the pipe, as shown

in the accompanying diagram, Fig. CCXCIX. The pipe must be so carefully cut to length as to require, when in proper tune, the shade to be no nearer to the open end than is shown in the diagram; otherwise an undesirable dullness may be imparted to the tone. The shades should be made of the toughest spotted metal, and of sufficient thickness to hold their position for any length of time.

Large open wood pipes may be tuned, in a manner somewhat similar to the above, by shades of wood, hinged to their backs, and held in proper position by stay-bars of hardwood, as indicated in the accompanying sketch, Fig. CCC. This method is simple, and does not disturb the tonal character of the pipes. Such large pipes are sometimes shaded by means of narrow boards laid flat on their open ends, and pivoted by screws so as to be easily moved in the process of tuning.

Other tuning appliances suitable for a large wood pipe are shown in Fig. CCCI. A portion of one of the sides of the pipe is cut away to a depth equal to about the width of the pipe, and a sliding piece of wood is placed so as to cover

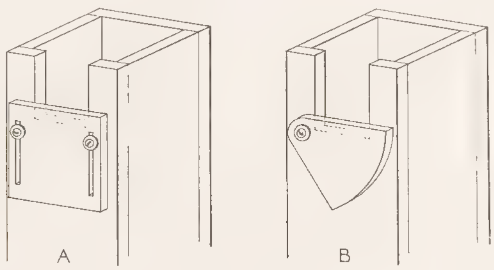


Fig. CCCI.

the opening to a greater or lesser degree, as required. The slider is held in place by two screws. This appliance is shown in the Diagram A. In Diagram B another and simpler means of tuning is shown. When wood pipes are made longer than their normal speaking lengths, so as to render them suitable for mounting, as ornamental features, in the organ-case or screen, their back boards are cut away to the necessary extent, or until their true speaking lengths are approached, and then either of the tuning appliances shown in Fig. CCCI. may be fixed in position.

There are certain classes of open wood pipes which require to be slotted near their open ends for the purpose of aiding the production of their characteristic tones. This is the case with the pipes of some imitative string-toned stops and certain pipes which yield tones of a reedy quality. Examples of these are furnished by the Violoncello pipes illustrated in Figs. CCLXXXV. and CCLXXXVI., and the Echo Oboe, Fig. CCLXXXIX. The tuning appliances of such pipes are connected with their slots, either in the form of adjustable slides of wood or in that of metal shades. In Fig. CCCII. are shown both the appliances. At A is the top of a slotted pipe fitted with a wooden tuning-slide, held in position by

two screws, and acting on the lower portion of the slot. This method of tuning is perfectly satisfactory in the case of the assertive string-toned pipes. At B is shown the metal-shaded slot, as found in the pipes of the beautiful Echo Oboe. To prevent the possibility of any unpleasant jarring, the side of the metal shade next the pipe is covered with soft leather.

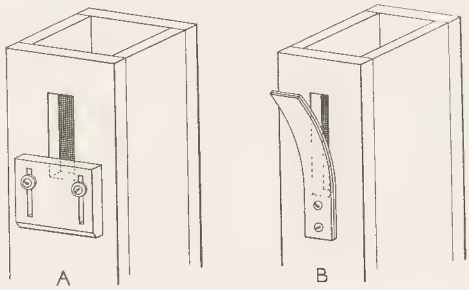


Fig. CCCII.

The several tuning appliances above described are the principal and representative ones used for open wood pipes. They are, as might be expected, met with in slightly altered forms in the works of different organ builders, but these modifications call for no special notice, especially as they are often compromises.

There is only one tuning appliance used for the stopped wood pipe; namely, the stopper which fits air-tight into the top of the pipe, and which has simply to

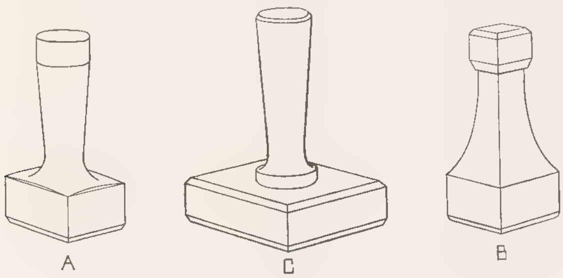


Fig. CCCIII.

be drawn up or pushed down in the process of tuning. Stoppers are made of different forms to suit the sizes of the pipes into which they are to be inserted. For small pipes they should be made from single pieces of wood, their handles being either turned in the lathe or shaped by the chisel into any convenient form. For large pipes, the portions which fit into the pipes should be slices of end-grained wood, or pieces carefully built up, having turned wood handles securely fixed in their centers. In Fig. CCCIII. the three forms of the stoppers just

described are shown. A and B are for small pipes, and C for large ones. In making stoppers, every precaution should be observed to prevent unequal or undue expansion and contraction; for the former may split the sides of the pipes, while the latter will destroy the air-tight character of the stoppers, and impair the tone of the pipes. All stoppers should be made considerably smaller than the pipes into which they are to be inserted, and then brought to the correct size by an edging of thin, springy felt and the outer covering of soft leather. If this method is carefully followed there is little risk, under all ordinary conditions, of either pipes being split or stoppers becoming loose. Stoppers of large size, such as those required for the Pedal Organ covered stops of 32 ft. and 16 ft. pitch, should be built up of two layers of white pine, glued together with their grain running crosswise, and edged with cork and felt. With the outer covering of thick and soft leather, such stoppers will give no trouble. A Section of a large stopper so formed is given in Fig. CCCIV., in which the different materials are clearly indicated, the dotted edging representing the cork, and the dark edging the felt. The outer covering is of soft sheepskin, with the undressed side exposed to come in contact with the inside surface of the pipe.

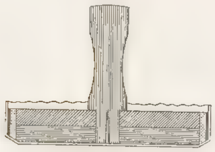


FIG. CCCIV.

There are certain wood stops, such as the ROHRFLÖTE and FLAUTO D'AMORE, the pipes of which are described as "half-covered." The stoppers of these pipes differ from the stoppers above described in having small holes bored vertically through them, as indicated in the illustrations of the FLAUTO D'AMORE pipe in Fig. CCLXXV. in the earlier part of the present chapter.

THE MITERING OF WOOD PIPES.

The mitering of wood pipes should never be essayed when there is any possibility of avoiding the operation; for no labial pipe is ever improved by any alteration from its original straight form. There are occasions, however, when long pipes have to be mitered so as to occupy certain cramped localities, or to stand in a swell-box which cannot be constructed of the proper height through insufficient accommodation provided for the Organ. On such occasions great care must be taken to so miter the pipes as to cause as little injury to their speech and tonal character as possible. As a rule, stopped pipes suffer less injury by mitering than open ones, apparently because there is no node created in their vibrating air-columns while they speak their fundamental tones: such being the case, it is not so important to study the position of the miter in a stopped as it is in an open pipe. The form of the miter is a matter of considerable importance, and under no circumstances should it be rectangular, as shown at A, in Fig. CCCV., for this abrupt form offers the maximum impediment to the free vibration of the internal air-column. It is always desirable to adopt a miter having an obtuse angle, such as is indicated in Diagram B; and it frequently happens such a miter is sufficient to

overcome a difficulty. When it is necessary to greatly reduce the height of a large pipe, a bend with a double miter usually meets the case. This form is shown in Diagram C. In some extreme cases it is necessary, on account of cramped space, to return the upper portion of a pipe to the vertical line, as indicated in Diagram D; but this treatment should never be attempted with an open pipe. In arranging the mitering of an open pipe it is desirable to keep as far above its central or nodal line as possible, for there is always a risk of impairing the free speech of the pipe in mitering it.

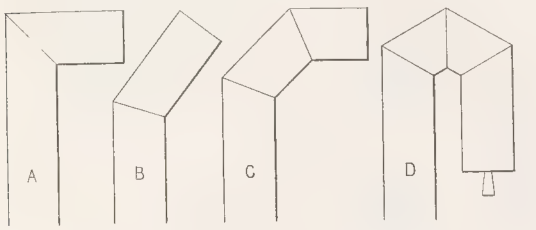


Fig. CCCV.

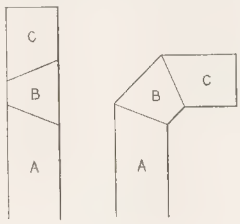


Fig. CCCVI.

The manner in which a straight pipe is cut to form a miter is shown in the accompanying diagrams in Fig. CCCVI. It is only necessary to turn the middle portion B around to form the double miter, as shown. All miters are made in a

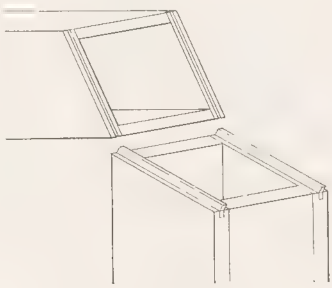


Fig. CCCVII.

similar manner. In putting the cut pieces together, all their sawn edges must be dressed so as to fit perfectly all around; and then two opposite edges are grooved in each piece, where they come together, for the reception of tongues of hardwood, as indicated in Fig. CCCVII. The edges are first sized with thin glue to stop absorption, and then well glued and pressed tightly together. To make the joints perfectly safe they should have a strip of strained leather glued around them.

When large pipes are mitered, it is desirable not to depend on the method of jointing above described, for it might give way in the course of a short time. To

make things secure, four slips of wood should be glued and screwed close to the joints which are tongued together; and then these flanges should be tightly bound to each other by screws, preventing the possibility of the mitered joints giving way.

THE STAYING OF WOOD PIPES.

While the wood pipes which are planted on the wind-chests of the manual divisions of the Organ are supported in a vertical position by the rack-boards through which their feet pass and in which they are tightly fitted, the larger wood pipes which belong to the Pedal Organ, or which may be mounted as appropriate features in the ornamental case or screen of the instrument, require to be strongly supported or stayed in their places. This staying is commonly done by fixing to

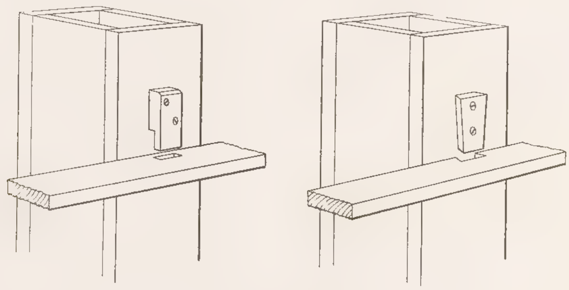


Fig. CCCVIII.

the backs of the pipes small projecting pieces of oak or some other hardwood, either notched out so as to form tenons or simply dovetailed, which fit into corresponding mortises or grooves cut in wooden stay-bars, secured to any convenient portion of the framework of the Organ or its surroundings. This simple arrangement allows the pipes to be readily moved and quickly replaced at any time. In the accompanying illustration, Fig. CCCVIII., are shown both the modes of staying just mentioned. In all cases care must be taken to bind the pipes firmly to the stay-bars so as to prevent any vibration or jarring while a pipe is speaking. When any tendency to jarring shows itself, the face of the stay-bar against which the pipe rests should be covered with soft leather or felt.

APPLIANCES FOR ALTERING THE PITCH OF WOOD PIPES.

There are occasions, in connection with the appointment of an Organ, when every legitimate expedient that can be devised to economize space and prevent over-crowding, recommends itself for serious consideration. And such occasions are not uncommon through the mistakes of architects in not providing adequate accommodation for the Organ in churches and other buildings. The department of the Organ which generally suffers most is the Pedal, the pipes of which are of

large size, and demand a considerable amount of standing and speaking room. It is in connection with such pipes that we now propose to offer some suggestions which, in extreme cases, may be found of value.

In constructing our own Chamber Organ we found great difficulty in accommodating the larger pipes of the PRINCIPALE, 16 FT., and had to devise means of dispensing with two of the larger pipes; namely, the CCC♯ and DDD♯. We were perfectly successful, by the introduction of simple appliances of a pneumatic character, in making the CCC and DDD pipes serve also for the CCC♯ and DDD♯ notes; and this without any appreciable effect on their proper intonation.

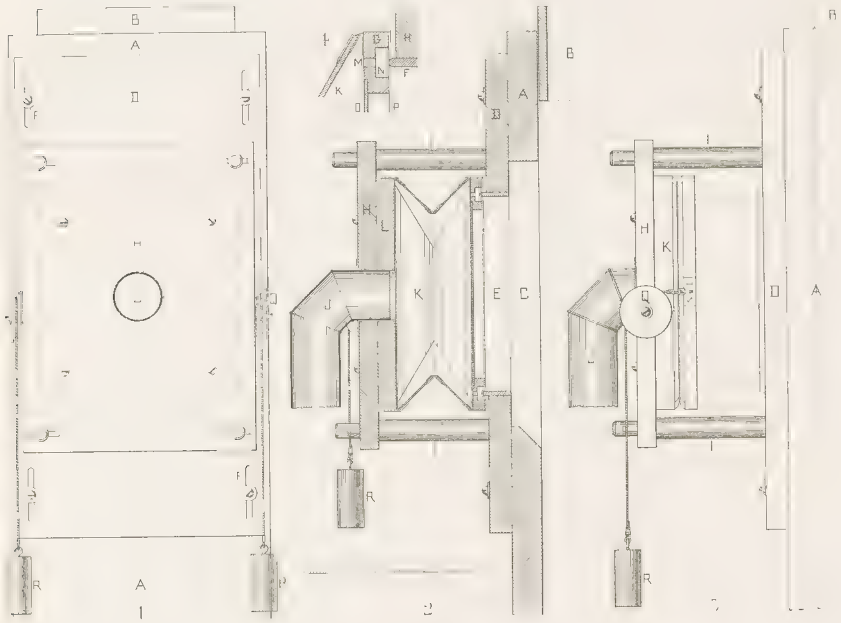


FIG. CCCIX.

As both the pipes alluded to are similarly treated, it will be sufficient to describe the appliance as attached to one of them. The CCC pipe, which is finished a trifle sharp to admit of final tuning, has a quadrangular hole, 10 inches by 8 inches, cut in one of its sides near the top, which, when uncovered, causes the pipe to speak the CCC♯ note, also somewhat sharp. The pneumatic appliance is attached to the pipe opposite this large hole, and is so constructed as to automatically close or cover the hole when the CCC key is depressed, and to immediately open it when the foot is removed from the key. When the CCC♯ key is touched, no movement takes place in the pneumatic valve, for the hole remains open, the

pipe speaking the CCC♯ note. The appliance alluded to is clearly shown in elevation and section in the accompanying illustration, Fig. CCCIX., and may be thus described:

In all the diagrams the upper end of the pipe, against which the pneumatic appliance or valve is placed, is indicated by the letter A. At B, as shown in the Vertical Section 2, is a sliding frame of thin wood, fitted to the inside of the pipe, and held tightly therein by a lining of leather or felt: this is for tuning the pipe to the CCC note. The oblong hole cut in the side of the pipe is indicated at C. The foundation of the pneumatic appliance is the board D, 10 inches wide by 20 inches long, in the center of which is the perforation, 8 inches square, E, around the edges of which is glued a thin slip or beading of hardwood, projecting slightly from the outer surface of the board, and forming the seat of the pneumatic valve when pressed against the perforation by the compressed air. This beading is shown at F in the enlarged Diagram 4. The board is secured to the side of the pipe by four screws which pass through slots, F, in the board, and which allow the appliance to be raised or lowered in the process of tuning the CCC♯ note. At about 5 inches from the face of the foundation board is carried, by four turned pillars I, the front board H, which has a circular hole 2 inches in diameter bored in its center for the reception of the metal conveyance J, through which the compressed air enters the expanding valve K. The valve K is made in the form of a small bellows, 9½ inches square, as shown, having a back board and a front frame, connected by wide ribs of strong cardboard, leathered, in the usual manner, with thin sheepskin. The back board L has a hole 2 inches in diameter bored through its center to correspond with that in the board H. These two boards are held together by four screws, as indicated in Diagram 1. The front frame, which is tightly mitered and keyed at its corners, is formed of channeled strips of light wood 1¼ inches by ⅝ inch, as shown in the enlarged Section of the frame 4. Small holes, M, are bored at intervals along the channel N, to allow the compressed air to enter it from the interior of the valve. The inside of the frame is covered with a square of cardboard, O, glued and tacked into a rebate; and the outside is covered with soft pallet leather, P, which comes in contact with the raised slip F of the square opening E. This leather, as it extends over the channeling of the frame, forms a soft and elastic cushion, as indicated in Diagrams 2 and 4, allowing the valve to bed securely and noiselessly when in action. Cords carrying metal weights are attached to the sides of the frame and carried over small wooden pulleys Q. These cords and weights, R, draw back the valve K the instant the compressed air is allowed to escape.

To adjust this appliance it is screwed over the opening C in the pipe and connected with the key mechanism by the conveyance J. The CCC key is then held down, and the pipe is tuned by the sliding frame B. The CCC♯ key is now depressed, the valve collapses, as it appears in the Side View of the appliance 3, and the pipe is tuned to CCC♯ by raising or lowering the whole appliance by means of the slotted foundation board D. The conveyance J is made to slide in an air-tight coupling piece in any convenient place in its length. The appliance is connected with the action of the CCC key only, because, as the pipe yields the CCC♯

note while the valve K is at rest, as it appears in the Side View 3, it is only necessary to set it in action, and close the opening in the pipe, when the CCC note is required.

Any convenient description of double-acting valve may be used to supply and exhaust the compressed air required for the appliance before described: but we shall only illustrate the slide-box which we devised for the purpose and inserted in our Chamber Organ, and which has the advantages of being noiseless and free from local pressure—advantages which simple disc- or conical-valve actions very seldom possess. The slide-box is shown in the Longitudinal Section, Fig. CCCX. The chamber A is supplied with compressed air from the bellows of the Organ, while the open portion B is for the escape of the exhaust. Above these are the two boards C and D, between which is the freely working slider E: all are pierced with four long and narrow ports, through two of which the compressed air passes

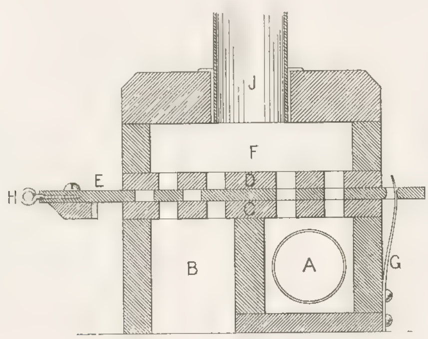


Fig. CCCX.

into the upper chamber F, and thence into the conveyance J when the slider is drawn as indicated. Through the other two ports the compressed air escapes from the chamber F when the slider is in. The spring G aids the key action in recovering the slider when the foot of the performer is moved from the actuating key. The tracker of the key action is attached to the slider at H. This slide-box should be located in a convenient position, as close as possible to the pipe, as previously described.

Instead of the slide-box illustrated in Fig. CCCX. a tubular-pneumatic appliance may be employed, in which a small primary pneumatic will command the action of a large secondary pneumatic carrying supply and exhaust disc-valves in the usual manner. Our own experience has taught us that no disadvantage attends the adoption of such an appliance as we attached to the CCC and DDD pipes of the Principale, 16 ft., in our Chamber Organ; for no performer ever discovered by the tones produced, that the two pipes did duty for four. Such being the case, so simple a means of meeting the difficulty of insufficient space may with perfect propriety be adopted in Chamber and small Church Organs.

CHAPTER XXXV.

METAL PIPES: AND THE MATERIALS USED IN THEIR CONSTRUCTION.

THE more important speaking stops of the Organ, both labial and lingual, are those formed of metal pipes. It is, accordingly, necessary that every care should be taken to employ the most suitable metals and alloys in their construction, so that the maximum durability and the best tonal results may be secured.

The materials suitable for metal pipes are tin, certain alloys of tin and lead, and pure zinc. The alloys are commonly known under the general term "metal"; but as this term conveys no idea of quality, or of the relative proportions of tin and lead used in their composition, it should invariably be attended by a statement of those proportions. This is certainly necessary on account of the inferior and undesirable material that is too often passed off on the inexperienced purchaser by the cheap organ builder under the seemingly satisfactory name of "pipe-metal," stuff little better than lead, stiffened sufficiently by the addition of antimony or old type-metal, to enable it to stand in the form of pipes, until the work is well out of the hands of the not over-scrupulous maker. Under these circumstances no reliance can be placed on the term "metal," when it appears in an organ specification unaccompanied by any statement or guarantee of quality. Purchasers of Organs should not overlook this fact, and should insist on having the compositions and specific gravities of the alloys used clearly stated. Any questions arising with respect to the alloys can be settled by having the specific gravity taken of cuttings from the pipe-work. There are few matters of more importance in an Organ than the quality of the metal used in the construction of its pipes.

TIN.—Of all the materials employed in the construction of metal pipes, English tin is unquestionably the best; and this fact has been recognized by all the great organ builders of the world. This metal closely resembles silver in white-

ness and lustre, and takes a polish almost equal to it, tarnishing very slightly under ordinary atmospheric conditions. It resists to a remarkable degree the action of impure air, generated by the breathing of large masses of people, and the corroding effects of the fumes sent off from burning gas, coals, etc.

Tin has the atomic weight of 118·8, and the specific gravity of about 7·3. It fuses at the low temperature of 442° Fahrenheit; and this fact constitutes the only serious objection, of a practical character, to its use in a pure state for organ pipes. Its easy fusibility renders the process of soldering extremely difficult and uncertain; for there is always as great a likelihood of the running solder melting the edges of the tin as of joining them, even when a special solder, fusing at a low temperature, is used. Such being the case, it has been found desirable to alloy the tin with a small percentage of pure lead, a proceeding which does not materially affect its desirable properties. When tin is used for front or displayed pipes, which are to be highly burnished, not more than 10 per cent lead should be added; for when a larger percentage is adopted, the whiteness and brilliancy of the tin are injured, and its burnished surface soon becomes tarnished. We understand that the standard "tin" used by Cavaillé-Coll for his MONTRES and other displayed pipes is composed of 90 parts pure tin and 10 parts lead: but the best builders of Germany seldom go beyond 75 parts tin and 25 parts lead, producing an alloy having a specific gravity of about 7·9942. This latter alloy, which passes in organ nomenclature as "tin," is quite sufficient for the pipes of any stop in the interior of the Organ.

In addition to the desirable properties just alluded to, tin recommends itself by its lightness, durability, malleability, and ductility—all properties that contribute to the production of perfect organ pipes. Tin also resists the action of any acid that may exist in the woodwork with which it remains in contact. Not only is tin comparatively light in itself, as shown by its atomic weight, but on account of its tough and stiff nature it can be safely used much thinner than any of the alloys in which lead predominates. These advantages go a long way to counterbalance its cost. Tin, as understood in organ parlance, is very seldom used at the present day for the larger stops, except when they furnish the external towers or displayed pipes of important instruments; but it is frequently and properly employed for such small-scaled and delicately-voiced stops as the DULCIANA, ÆOLINE, and VOX ANGELICA; for all the metal imitative string-toned stops; and for the tubes of certain forms of ORCHESTRAL OBOE, VOX HUMANA, and other reed stops of delicate intonation.

Tin, in as nearly a pure state as can be satisfactorily worked, is unquestionably the best of all materials for front or displayed pipes. Its beautiful silver-like appearance when polished or burnished is both highly effective and refined; it harmonizes well with all the richer-tinted woods of which organ cases may be fabricated; and it renders gilding or painting unnecessary. Under all ordinary conditions and good usage it is practically indestructible, and its brilliancy can be restored at any time. The total absence of all necessity for painting is a decided advantage, seeing that the art of decoration, so far as organ pipes are concerned, is very little understood. There are several methods of decorating metal pipes

that are highly artistic; but these demand cultivated taste and skilled labor. In the matter of cost, it is questionable if speaking pipes of burnished tin of the best quality would prove so expensive as pipes of good metal, artistically and appropriately decorated. Of course they are more costly than the miserable zinc dummies, smeared with paint and stenciled with commonplace and vulgar patterns in inharmonious colors, such as are usually produced in too many of the organ-building establishments in England and America to-day.

English tin has always been the favorite material with the German and French organ builders, and it was also much favored by the old English masters. We have before us as we write, among our specimens of old pipe-materials, a small piece cut from the back of one of the front pipes of the small Organ in Tewkesbury Abbey, made by Harris in the year 1637, or by his grandson Renatus Harris in 1690. This piece shows no trace of corrosion; and its edge, cut about fifteen years ago, remains brilliant to the present time. Many of the old front pipes of this instrument are richly embossed with different patterns. In late times—the times of cheap and competitive organ-building—polished tin pipes have been rarely introduced in English and American Organs, a fact that is greatly to be regretted both on artistic and utilitarian grounds. In specifying "fine tin" for burnished and displayed pipes, and also for the imitative string-toned, and the imitative and more delicate-toned reed stops, the alloy composed of 90 per cent pure English tin and 10 per cent pure soft lead should be clearly stated. For other special interior pipe-work, "tin" composed of 80 per cent pure tin and 20 per cent lead will prove perfectly satisfactory. This latter alloy has, according to Töpfer, a specific gravity of 7·8830. The term "tin" should cease to be employed, without some distinct qualification, for an alloy which contains less than 80 per cent of that metal. All alloys inferior to this in the amount of tin should be described as "metal."

In the specifications of important German Organs two alloys are sometimes mentioned under the names of "Englisches Zinn" and "Probezinn." The former is pure English tin alloyed with about 10 per cent lead, while the latter is an alloy containing about 25 per cent lead. In the published description of Walcker's large Organ in St. Petrikirche, at Hamburg, we find both terms used. The PRINCIPAL, 16 FT., and the PRINCIPAL, 8 FT., in the Great Organ, are of "Englischem Zinn," and all the other metal stops throughout the instrument, with a single exception, are of "Probezinn," described as "12 löthig." This informs us that the alloy contains in 16 Loth—one pound—12 Loth of tin and 4 Loth of lead; that is, 75 per cent tin and 25 per cent lead, having the specific gravity of 7·9942. This practice of stating the composition of a pipe-metal is to be highly commended. It is worthy of note that the ROHRFLÖTE, 4 FT., in the Great Organ, is the only stop stated to be of "Metall."

The present English tin, and that preferred by the most respectable organ builders all over the world, for their highest-class work, is known as the "lamb stamp," or "lamb and flag" tin. For the production of certain qualities of spotted metal this is sometimes mixed with Banca tin.

LEAD.—In anything approaching a pure and unalloyed state lead is absolutely

worthless for the construction of organ pipes. It has, nevertheless, been frequently used, stiffened and rendered brittle by the addition of some old type-metal or antimony, by unprincipled organ builders, and palmed off on ignorant and unsuspecting clients under the ambiguous name "pipe-metal." One remarkable instance of its use is mentioned by Hopkins, who tells us that it was used for all the metal pipes in the Organ in the Minoritenkirche, at Bonn, the instrument on which Beethoven performed. This notable instance goes no way to authorize or excuse the use of so base a metal in modern instruments. Mr. F. E. Robertson, in his "Practical Treatise on Organ-Building," mentions an Organ that was built by a London firm for a cathedral in one of the Presidency towns of India, in which the metal pipes were "pure lead," and so thin that a tenor C pipe could be easily ripped by the fingers. He facetiously remarks that "the eminent builders would doubtless have assured the purchaser that 'plain metal' was good for tone;" and that "it would have been interesting to get their opinion on their pipes after twenty years." He suggests a possible excuse for the builders; but, in fact, there can be no excuse for such disreputable work under any conditions.

Lead is a very soft, heavy, and malleable metal of a bluish-gray color. When freshly scraped or cut, it presents a lustrous surface, but this quickly becomes dull from the formation of a film of oxide. It cannot be polished or burnished on account of its extreme softness. Its atomic weight is 206·9, nearly twice that of tin; and its specific gravity is about 11.4. It fuses at the temperature of about 617° Fahrenheit, or 175° higher than that at which pure tin melts: and it is this fact that renders it a valuable alloy for tin, enabling it to stand the heat of molten solder and the soldering-iron.

Pipe-Metal. — Under this term, or under the shorter and more usual one of "metal," are included all the alloys of tin and lead used in pipe-making, which do not, in organ nomenclature, receive the more distinguished name of "tin," as already explained. The simple term metal is, accordingly, ambiguous and generally misleading, inasmuch as it is frequently employed to designate an alloy which contains the smallest percentage of tin that the elastic conscience of the cheap organ builder will allow him to indulge in; while, on the other hand, it may be employed to designate all the other alloys which range from the poorest quality up to the high-class alloy containing 75 per cent pure tin. The term "metal," accordingly, in itself conveys no further idea of quality or character than the presumption that it is an alloy of tin and lead. We use the word presumption because the name has frequently been given to alloys of lead and antimony, innocent of the slightest admixture of tin.

In face of this uncertainty and ambiguity, it is desirable that some certain test should be resorted to to protect the purchasers of Organs against imposition. The most satisfactory test, and one that cannot well be disputed, is furnished by the specific gravity of the alloy in question. As the specific gravity of tin is 7·3, and that of lead is 11·4, it is obvious that all the alloys of tin and lead will have specific gravities ranging between these figures. For this test to be conclusive it must first be ascertained that the metal is an alloy of tin and lead. As the specific gravity of antimony is 6·7, it follows that the specific gravities of alloys of that

metal and lead will range between 11·4 and 6·7, so they might easily be confounded with some of the poorer alloys of lead and tin. Antimony metal can, however, always be detected by its brittle character. Type-metal illustrates this in an extreme degree.

The specific gravity of a body is the ratio of its density to that of some standard substance. For solid bodies, such as the metals, water is adopted as the standard. As the weights of metals are proportional to their masses, it follows that the specific gravity of a metal is equivalent to its relative density; accordingly, the term *density* frequently displaces the term *specific gravity* in scientific treatises. When the latter term is used, the standard substance is understood to be distilled water at the temperature of 62° Fahrenheit: when the term density is used, the standard is understood to be water at its maximum density, at the temperature of 4° Centigrade (39·2° Fahrenheit).

To ascertain the quality of pipe-metal, by finding the relative proportions of tin and lead in its composition, it is only necessary to suspend a small piece of it by a very fine thread or human hair from one of the scales of a sensitive balance, and weigh it accurately in the air, noting its exact weight in grains; then to lower the balance over a vessel containing distilled water, until the suspended piece of metal is completely submerged, taking care to remove any air-bubbles that may cling to its surface, and again weigh it accurately, noting, as before, its exact weight in grains. Finally divide the weight in air by the loss in weight in water, and the product will give the specific gravity of the pipe-metal.

The following Table gives the specific gravities of twelve different alloys of tin and lead. This will render special calculations unnecessary, for the character of any alloy, the specific gravity of which has been found, may be readily known by reference to the Table:

THE SPECIFIC GRAVITIES OF ALLOYS OF PURE TIN AND LEAD.*

PROPORTIONS OF TIN AND LEAD.		SPECIFIC GRAVITIES.
Pure Tin		7·3000
4 parts Tin	1 part Lead	7·8830
3 " "	1 " "	7·9942
5 " "	2 " "	8·1094
2 " "	1 " "	8·2669
3 " "	2 " "	8·4973
1 " "	1 " "	8·8640
2 " "	3 " "	9·2653
1 " "	2 " "	9·5535
2 " "	5 " "	9·7701
1 " "	3 " "	9·9387
1 " "	4 " "	10·1832
	Pure Lead	11·4000

* Derived chiefly from "Die Theorie und Praxis des Orgelbaues," by Töpfer-Allihn. Weimar, 1888, p. 185.

A pipe-metal containing as little as 15 per cent tin is very commonly used in certain quarters; indeed, it is quoted for in the price list of one of the largest manufacturers of organ pipes in existence to-day; but we do not advise its adoption in any class of pipe-work. The alloy given in the above table, composed of 1 part tin and 4 parts lead, having the specific gravity of 10·1832, is the lowest grade of pipe-metal that should be used under any circumstances, and then only for stops of secondary importance. We recommend no alloy under that composed of 1 part tin and 3 parts lead, which has the specific gravity of 9·9387. Even this latter metal should only be used for the less important large-scaled stops. In really good work no alloy inferior to that known as "spotted metal" should be employed. Pipes made of this metal, when of proper thickness, are perfectly satisfactory in tone, durability, and appearance. We allude to their appearance, because pipes made of the finest quality of spotted metal, protected by a colorless varnish or lacquer, are well adapted for display when those of burnished tin cannot be afforded or readily obtained.

When a certain percentage of fine tin is melted with pure lead and cast in the usual manner, the surface of the sheet develops a richly-mottled or spotted appearance as it sets. This appearance is a certain guarantee of good quality; for a really fine spot cannot be obtained in an alloy having less than 45 per cent pure tin, or say a higher specific gravity than 9·06. This is the percentage of tin used for spotted metal in the large pipe-making establishment of August Laukhuff, at Weikersheim, Württemberg. Finer qualities of spotted metal are produced by larger proportions of tin up to 55 per cent. So rich is the alloy in which 55 per cent pure English tin is introduced, that the term "confluent metal" has been employed, instead of the ordinary term spotted metal, to distinguish it. In this high-class metal the spots are so small and so close together as to present a surface almost uniformly bright, hence the name "confluent metal." It must be observed that the smaller and closer the spots are, the higher is the percentage of tin in the alloy. Large and somewhat dull spots, irregularly disposed, and having boldly-marked intervals between them, are indicative of comparatively poor metal. So reliable is confluent metal, composed of 55 per cent lamb stamp tin and 45 per cent pure lead, that it can be safely used for every important metal stop in a high-class Organ. Pipes constructed of it will, with proper care, last for centuries.

Plain pipe-metal is an alloy in which the percentage of lead greatly exceeds that of the tin; and unfortunately it does not present any external indications, beyond a dull gray tint, whereby its quality may be readily detected. Experienced persons can, of course, arrive at a fairly accurate estimate of its quality, but the only conclusive proof is its specific gravity. Pipes made of metal having a greater specific gravity than 10·1832—that is, containing less than 20 per cent tin—should never be allowed in an Organ. A fair plain pipe-metal is composed of 35 per cent pure tin and 65 per cent pure lead, having a specific gravity of about 9·65.

Although it is not necessary in the present treatise to go fully into the method of casting the sheets of pipe-metal, the present Chapter would be obviously incomplete without a brief outline of the process.

The proper proportions and quantities of tin and lead having been provided, the lead is first put in the melting-pot, which is usually a strong cast-iron pot built in over a suitable furnace; and when it is melted, and any dross that may rise to the surface is removed, the tin is put in and a little tallow and resin is added. The alloy is now well stirred so as to thoroughly incorporate the lead and tin; and when this is done and the surface is carefully scummed to remove all impurities, it is ready for casting. In the melting an excessive temperature should be avoided, only sufficient heat being applied to thoroughly fuse the lead, which will be slightly in excess of 617° Fahrenheit. The molten alloy is ladled into a sheet-iron trough or vessel hinged to one side of a wooden casting-box, which is so constructed as to slide on a guide along a perfectly level bench or table covered with thick cotton cloth. The casting-box is in reality a frame of hardwood, without either top or bottom, which rests on the cloth covering of the bench, its ends and one side being in close contact with the cloth, while the remaining side is slightly raised, leaving a narrow opening through which the molten metal is deposited, of the required thickness, on the surface of the cloth in the process of forming the sheet. This side of the casting-box is made adjustable, so that altering the space between its lower edge and the cloth produces sheets of different thicknesses. A guiding-bar is attached to one of the ends of the box, which slides on the edge of the table and retains the box in proper position. The casting-table is usually constructed of wood, strongly put together and braced in all directions so as to prevent its twisting, and its top is of thick plank planed perfectly level and true. But as even under the most favorable conditions wooden tables have been found to warp and become uneven in the course of time, table tops formed of perfectly flat slabs of slate or soapstone have been advocated by builders who pay proper attention to every detail of their art. Slate is used by Mr. Philipp Wirsching, of Salem, Ohio, who informs us that from a table of this material sheets can, without fail, be produced perfectly uniform in thickness, and of beautiful appearance. Over the table, in all cases, strong and smooth cotton cloth is tightly stretched by being drawn down over its edges and securely tacked to the woodwork below. At one end of the table is placed a sheet-iron trough to receive any metal that may be left over when the casting is finished. The casting-box is first placed at the end of the table opposite that just alluded to, with a sheet of paper between it and the cloth, the opening, deciding the thickness of the sheet to be cast, being toward the end of the table. All is now ready for the casting. When the molten metal, which has been ladled into the trough hinged to the casting-box, is found to have reached the temperature at which it will flow easily without burning the cloth, the metal is poured into the casting-box, and the box is run along the table, leaving a sheet of metal of uniform thickness and width on the surface of the cloth. When spotted metal is being cast it is at this stage that the surface of the sheet assumes its distinctive appearance. When the sheet has set, its ends are released so as to prevent any rupture through unequal contraction; and when sufficiently cold, it is rolled up and placed on end for use. Such is an outline of the process, with many details, more or less important, left unmentioned. It is difficult to clearly and fully describe a process like this without the aid of sev-

eral illustrations: but the reader who desires further information, and has no opportunity of visiting an organ manufactory, may refer to Plates XLIV., XLV., and XLVI. of "L'Art du Facteur d'Orgues," by Dom Bedos, or the illustrations given in the modern and more accessible works entitled "Nouveau Manuel Complet du Facteur d'Orgues" (Paris 1903) and "Die Theorie und Praxis des Orgelbaues" (Weimar 1888), both of which reproduce some of the illustrations given by Dom Bedos.

Zinc.—The use of zinc in organ-building is of recent date, no record of its employment by the old masters having been found. Zinc is a gray metal, having the atomic weight of 69·9, and a specific gravity of about 7·0. It is more tenacious than tin, lead, and any of the alloys of these two metals. In its cold state it is peculiarly stiff and difficult to work, being malleable only at about the temperature of boiling water, or between 200° and 250° Fahrenheit: accordingly, in the forming of pipes it requires to be heated to some extent. The sheets from which pipes are made are produced by rolling, not by casting in the manner adopted for the alloys of tin and lead.

Zinc has been largely used of late years in the construction of large pipes, and frequently for those forming the bottom octave of stops of 8 feet pitch. It is not to be wondered at that zinc has met with favor in the organ-building world, simply because anything that is cheap and sufficiently durable to last a reasonable time will find warm advocates among competitive builders, who are called upon by unwise clients to produce Organs at prices far too low to command the best materials and workmanship. It may be safely said that for really high-class work, intended to last for a long period of time, zinc should never be used. Had the larger pipes of the Organ in St. Bavon's, at Haarlem, constructed in the year 1738, been made of zinc, instead of English tin and an alloy containing 50 per cent tin, the instrument would be a very different thing from what it is to-day with its pipe-work sound and good, even had it lasted so long in its original state, which is extremely doubtful we venture to think. The only qualities that recommend the use of zinc for organ pipes (setting aside its cheapness) are its lightness and stiffness. The latter quality leads to its abuse in the hands of inferior builders, who, to save money, reduce its thickness to the utmost limit. When zinc is used for speaking pipes it should be of ample thickness. The most legitimate, and in our opinion the only desirable, use of zinc is for the construction of dummy pipes which are to receive painted decoration. Mr. Laukhuff manufactures zinc pipes in different styles of finish; namely, nickel-plated, tinned outside and inside, gray-lacquered, bright, and plain. All pipes save those of plain zinc are intended to be exposed, and are protected with a colorless, transparent lacquer.

When labial pipes are made of zinc, their languids, upper and lower lips, and the tips or toes of their feet must be formed of good pipe-metal, preferably spotted or confluent metal. This is absolutely necessary to allow these parts to be properly manipulated in voicing and regulating: and in certain cases pipes, which require the tops of their bodies to be manipulated in voicing and tuning should have short lengths of pipe-metal soldered to them. Thick zinc is a most stubborn material, very difficult to cut or bend. Something may be said in favor of the use of

zinc, of good substance, for the feet of heavy metal pipes, for here there can be no objection urged against it on the score of sound production: of course there still remains the question of durability which deserves consideration. Zinc has been recommended and used by certain good builders for the slender tubes of reed pipes which are very liable to break or bend when of ordinary pipe-metal. Such tubes should have their upper ends or bells formed of pipe-metal so that they may be readily cut or otherwise manipulated. The CONTRA-SAXOPHONE, 16 FT., (free reed) made for us by the late Hilborne L. Roosevelt, of New York, has its tubes made of zinc finished with ample lengths of spotted metal at their upper ends. It may be taken for granted, notwithstanding the fact that zinc is now used for pipes by some distinguished builders, that it is adopted solely on account of its comparative cheapness. It certainly can lay claim to no other advantage over really good pipe-metal.

To what extent the different metals and alloys used in the formation of organ pipes affect the tones of pipes is a question that has never been, and probably never will be, satisfactorily answered, and this notwithstanding the statements made by certain writers on the Organ. Many years of careful and unprejudiced observation have had the effect of making us anything but dogmatic on one side or another. We have heard tones in every way satisfactory produced from pipes constructed of practically all classes of pipe-metal and alloys—from the poorest and deadest alloy of lead and antimony to the richest alloy of tin and lead. We have heard the most perfect imitations of the tones of the Violin and Violoncello produced from pipes of spotted-metal;—such imitative and beautiful tones as we have never heard from pipes of tin;—and we have known such choice pipes to be joined in the bass octave by pipes having bodies of zinc, without any perceptible break in tone where the spotted-metal ones ended and the zinc ones began. We have known one voicer to produce a better tone from pipes of almost pure lead than another was able to produce from similar pipes constructed of rich confluent metal. And such experience and observation, extending over a period of more than thirty-five years, in connection with French, German, English, and American organ-building, leaves us with the conviction that art has more to do with high-class tone production than has mere material: and although in general and artistic practice certain classes of pipes appear to be most satisfactory in tone when formed of tin or fine spotted metal, their tonal character and excellence depends chiefly, if not altogether, on their correct scaling, proper thickness of material, perfection of formation, the pressures of wind that are used, and, above all, on the skill and musical sense of their voicers. It is on the score of strength, rigidity, and durability that the higher-class alloys of tin and lead are to be advocated for all the metal pipes of the Organ. One has only to look at such a landmark in the art of organ-building as the noble instrument in the Church of St. Bavon, at Haarlem, to realize the value of such materials: its pipe-work—one hundred and sixty-eight years old—is practically as good to-day as when it was made. Whatever alloy is used for the pipe-work of the Organ, care must be taken to have it of ample thickness in all the foundation stops. It is impossible to obtain the grand rolling tones which should characterise the PRINCIPALS or OPEN DIAPASONS from pipes

having thin and light walls. No consideration or expense should be allowed to influence the pipe maker in this matter. Scale, pressure of wind, and the volume of tone required, should alone dictate the thickness and weight of the metal used in pipe construction.

Various other materials have been used in pipe construction which might seem to claim our consideration in a Chapter like the present; but as they have never been generally accepted in practical organ-building, and will always be classed among the curiosities of the art, we need not devote valuable space to their description.

CHAPTER XXXVI.

METAL PIPES: AND THEIR MODES OF CONSTRUCTION.

HAVING given, in the preceding Chapter, an outline of the process of casting the alloys of tin and lead into the form of thin sheets, suitable for the construction of all classes of metal pipes, it is only necessary for us to commence our brief survey of the process of pipe-making at the point when the sheet of metal lies finished on the casting-bench. We presume, for our present purpose, that this sheet is of spotted metal, and that it exhibits all its virgin brilliancy and richness of effect. It is desirable that this brilliancy shall be retained throughout all the subsequent processes until the pipes formed from the sheet are finished, ready for voicing. The first proceeding, therefore, is to protect the bright spotted surface so that it can be freely handled without injury. This protection is commonly given by coating the surface with a mixture of distilled or rain water, the finest glue size, and precipitated whiting or Paris white. Just enough size must be added to render the coating tough and not liable to scale or rub off. When it is considered desirable to have the spotted character of the sheet kept in view, instead of the above composition a coating of gum arabic dissolved in rain water should be used.

It is desirable to select sheets of suitable thicknesses for the bodies of the larger pipes, say, of such a stop as the PRINCIPAL, 8 FT., because it is always an advantage to retain the surfaces left in casting, which give the maximum firmness to the metal. For the smaller pipes, say, from middle c^1 to the top pipe, the metal is usually planed, on the non-spotted side, to the required thicknesses. For this purpose an iron plane is used, in which the blade is set more upright than in the plane used for wood. In all cases the inside surface of the metal employed for pipe-feet must be planed, because it is essential that the inner edges of the lower lips of the pipes are perfectly smooth.

When ordinary plain metal is used in pipe-making, the upper or outside surface of the sheet (as cast) is planed and scraped level and smooth, and, properly, coated with the mixture of size and whiting as above described. When tin (the alloy of 90% tin and 10% lead) is employed, the sheet is also planed and carefully scraped with a sharp steel scraper. For all displayed pipes the tin sheet is planed, scraped, and highly burnished. The German and French organ builders, who have always paid great attention to the proper construction and finish of tin pipes, have displayed much skill in the burnishing process—that on which the brilliancy and durability of metallic surface chiefly depends. After the sheet is properly cast, planed, and scraped to a perfectly uniform and smooth surface, the German workman burnishes the same with a broad, rounded, and highly-polished agate burnisher fixed in a wooden handle, lubricating the surface of the sheet with a good lather of pure soap and water. Under the proper application of the burnisher the surface of the tin assumes a brilliant polish and becomes close and hard. This surface is finally protected in the manner already directed for the sheet of spotted metal. The sheet intended for the bodies of pipes, which has been treated in any one of the methods above described, is ready to be coated with the sizing of glue and whiting on its under or inner surface, and to be cut into the forms proper for the construction of pipes. The sheet from which the pieces required for the pipe-feet are to be cut should not be coated all over with the sizing on its inner surface.

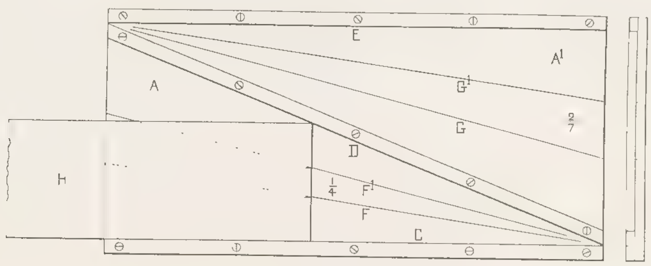


Fig. CCCXI.

For the cutting-out process the following appliances and tools are required: A properly-divided scale, giving the exact circumferences of the bodies of all the pipes belonging to the stop to be made; a rod giving the lengths of all the bodies; the appliance for accurately determining the widths and central position of the mouths of all the pipes; the patterns or templates, giving the sizes and shapes of the pieces of metal required to form the conical pipe-feet; a straight-edge; a scratch-hook; a blunt marking-tool; and compasses for transferring the circumferences from the scale. The scale is usually a strip of brass or zinc on which are marked the circumferences of all the pipes forming the stop, set out from a datum-line. The rod giving the lengths of the pipe-bodies is of wood, marked with the lengths

set out from a datum-line. The lengths are calculated with reference to the scale of the pipes, the nature of the stop, and the wind-pressure on which the pipes are to be voiced. The smaller the scale the greater the length; and the higher the wind-pressure the greater the length of the pipe-bodies. The appliance for accurately determining the widths and central position of the mouths of the pipes is shown in the accompanying diagram, Fig. CCCXI. It consists of the oblong board A and A^1, on which are glued and screwed the three slips C, D, and E, dividing the surface into two triangular compartments. Exactly in a central position in each compartment is indicated, by two radiating lines, the width of the mouth. In the compartment A the lines F and F^1 define a mouth of a width equal to one-fourth the circumference of the pipe, which is embraced between the slips C and D. In like manner, in the compartment A^1, the lines G and G^1 define a mouth two-sevenths of the circumference, which is embraced between the slips D and E. At H is indicated the mouth end of a piece of metal cut for the formation of a pipe-body. This will be spoken of more particularly farther on. The patterns or templates giving the forms and relative proportions of the pieces of metal required for the conical pipe-feet are accurately set out and cut from strong sheet zinc. The manner in which the templates are set out is indicated in Fig. CCCXII. A is a

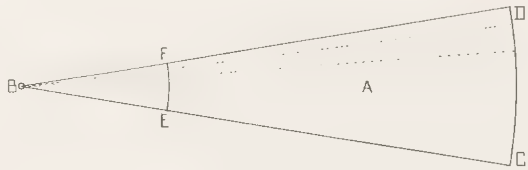


Fig. CCCXII.

template, the sides of which are defined by the lines radiating from the point B to the corners C and D. The arc C—D is struck from the point B, and is a trifle longer than the exact width of the piece which is accurately cut to the circumference of the pipe-body. From D to F is the required length of the pipe-foot; and from E to F is the circumference of the tip or toe of the foot before its final manipulation. The dotted lines indicate templates for pipes of smaller circumferences measured from C. The templates are not necessarily of the same length, those for the bass and tenor pipes may, very properly, be longer than those for the smaller pipes. No pipe-foot should be less than 7 inches in length. The straight-edge, used for guiding the scratch-hook in cutting out the pipe-bodies, is, preferably, a flat bar of steel, planed perfectly straight along its edges, and of sufficient thickness to properly guide the scratch-hook. The scratch-hook is a small triangular rod of steel, the end of which is bent to a right angle and ground so as to form a V-shaped cutting point, the angle of which should be 45°. The scratch-hook is securely fixed in a wooden handle. The blunt marking-tool is simply a blade of steel having a rounded edge and point, so that it can make an indentation in the

metal sheet without in any way cutting it. The compasses are of the ordinary form used by mechanics: they should be large and provided with the usual fixing-screw and arc.

In cutting out and preparing the pieces of metal required for the bodies and feet of the pipes, say, of a PRINCIPAL, 8 FT., the following processes are adopted: The sheet of metal, cast and subsequently treated as above described, is laid flat on the cutting-table, and one of its edges is cut perfectly straight by means of the straight-edge and scratch-hook, and its end is cut square to the edge so formed. The length of the body of the pipe is now marked on the sheet from the wooden rod already mentioned, and by means of the compasses, carefully set to the pipe-scale, the circumference of the body is marked on the sheet, from the cut edge, at both ends of the length indicated. The straight-edge is now accurately adjusted to the compass marks, and the other edge of the body-piece is cut with the scratch-hook. The same method is followed at the end of the piece, which is now detached from the sheet and laid carefully aside, ready for subsequent manipulation. In cutting, the scratch-hook is firmly drawn toward the workman; and when properly used it leaves the edges of the metal on both sides of it practically in a fit state for soldering. Care must be taken not to injure the edges in any way. All the pieces required for the pipe-bodies are cut out in precisely the same manner.

In cutting out the cuneiform pieces required for the pipe-feet, a strip of metal of a width sufficient for the length of the feet is prepared, and on its outer or spotted surface are laid, and arranged in the most economical manner, the patterns or templates. The surface is carefully marked to the forms of the several templates to guide the cutting-out. Then the straight sides of the pieces so marked are partly cut through—the cuts being carried entirely across the strip of metal—by means of a straight-edge and the scratch-hook. The latter tool, in the process of cutting the deep V-shaped incisions, causes indications of its operations to become visible on the under or planed side of the strip. The strip is now turned on its face, and along the lines so indicated narrow bands of sizing are laid on with a brush. These edgings of size are to prevent any solder adhering to the inside of the pipe-feet while their joints are being soldered externally. The foot-pieces are then completely separated by being bent along the incisions, and are so far finished by having their arched ends carefully cut with shears. They are now laid aside in proper order for future manipulation.

The next part of the process of pipe-making is to properly mark on the body-pieces the exact positions and widths of the pipe-mouths. This is done by means of the simple appliance already described and illustrated in Fig. CCCXI. The manner in which a body-piece is adjusted in this appliance is indicated at H. It rests closely along the lower strip C, while the end is held in the correct position by the diagonal strip D. So placed, the lines F and F^1 indicate, at the end of the body-piece, the exact proportionate width of the mouth (one-fourth the width of the piece or circumference of the pipe) and the correct locality of the same. The piece is placed face downward, and the width of the mouth is scratched on the exposed surface, as indicated by short lines. From these lines indentations have

to be made extending from the edge a distance equal to half the width of the mouth. These indentations, which favor the accurate formation of the mouth, are made with the blunt marking-tool, guided by a small straight-edge, which, sliding against the diagonal strip D, always presents its marking-edge truly parallel to the lower strip C. The entire appliance, showing the application of the sliding straight-edge and the mouth indentations, is represented in Fig. CCCXIII. The

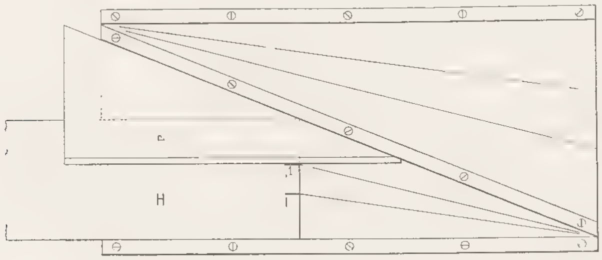


Fig. CCCXIII.

sliding straight-edge is shown at J, and the indentations on the body-piece are indicated at I and I¹. The body-piece is now ready to be rolled up on a mandril, but before that part of the process is essayed it is necessary for the width and position of the mouth to be transferred to the upper arc of the corresponding foot-piece. The manner in which this transferring is best accomplished will be understood from the three diagrams given in Fig. CCCXIV. The body-piece H is laid

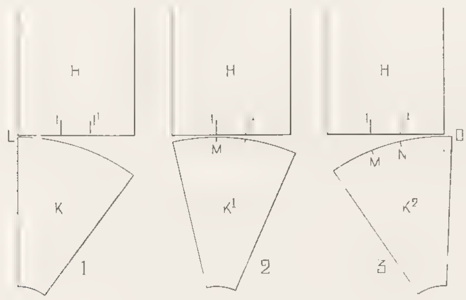


Fig. CCCXIV.

face downward on the cutting-table, and held firmly thereon by a weight or any other convenient means. The corresponding foot-piece K is placed, also face downward, against it, in the position indicated in Diagram 1, the straight edges on the left hand being adjusted accurately in line, as at L. The foot-piece is now rocked,

without allowing it to shift its relative bearing, until its arc touches the first mouth-indentation I, as indicated in Diagram 2. While in this position the foot-piece K¹ is marked at M. The rocking motion is then continued, and after the second mark for the mouth has been made at N, the foot-piece K² is brought to the position indicated in Diagram 3. This last position determines the correct length of the arc. As the foot-piece is usually cut out a trifle full, as shown at O, the excess is accurately marked and subsequently removed. The mouth-marks M and N are indented similarly to those in the body-pieces, but are made very short, not exceeding ⅜ inch in the CC pipe.

Before entering on the rolling-up and soldering processes we may properly describe the casting and preparation of the languids. The alloy used for the languids should be rich in tin, for it is essential that they should have no tendency to sink when fixed in the pipes. When the metal used for the pipes is of good quality it is always advisable to have the languids of the same quality. The molds commonly employed for casting the strips of metal from which the languids are to be cut, are formed of two boards, shaped, and held the required dis-

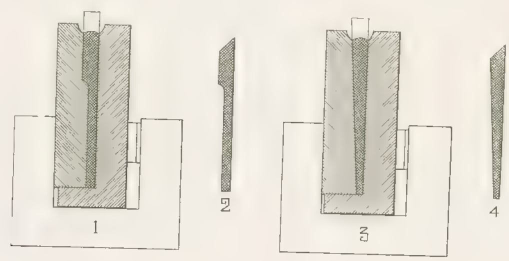


Fig. CCCXV.

tance apart by slips of wood placed between their ends. In Fig. CCCXV. are shown two Transverse Sections of languid molds yielding strips of metal of the shapes usually adopted for the languids of pipes of different dimensions. The mold shown in the Transverse Section 1 produces the form of languid suitable for large pipes, while the mold indicated in the Transverse Section 3 produces the form of languid commonly used in pipes of medium size. The very small pipes have languids formed from strips of metal of uniform thickness. When the strips of metal are removed from the mold their front parts are planed to the proper graduated thickness to suit the several languids to be cut therefrom, and then planed to the angle of 45°, as indicated in the Sections 2 and 4. The thickness of the front of a languid should, as a general rule, be one-fourth the height of the corresponding mouth, the standard height of which is one-fourth its width. The strips of metal are now sawn into pieces of the requisite size to form the several languids, and laid aside, in their proper order, until they can be fitted to their respective pipe-feet.

In the proper order of things, the pieces of metal cut for the bodies of the

pipes are now rounded up by being pressed around cylindrical mandrils, which have circumferences somewhat larger than the widths of the body-pieces. Considerable care and skill are required in this process, as it must be conducted without any beating calculated to expand the metal and render the edges uneven. The most convenient way of rounding up is to place the mandril in proper position on the piece of metal, and then by means of a feather-edged strip of wood, slipped under the near edge of the metal, to bring the latter tight against the mandril, and, so holding it, to roll the metal around the mandril, subsequently pressing the metal closely against the surface of the mandril by the wooden article called "the beater." This last treatment is strictly a smoothing, not a beating one. When the metal is removed from the mandril, its splayed edges should be a small distance apart and truly parallel, so as to be easily pressed together in the subsequent process of soldering. The pieces prepared for the pipe-feet are rounded up on conical mandrils, in the same manner as above described for the cylindrical bodies.

When all the bodies and feet have been rounded up, the next process is that of soldering. In briefly describing this, we may confine our remarks to a single piece. The piece, which has been properly sized, as previously directed, is taken and its splayed edges are scraped perfectly clean with a sharp tool and immediately rubbed with pure stearine. Only as many joints should be so treated as can be soldered within a few hours. The edges are now pressed tightly together and secured by a few touches of solder at intervals. Now, while the piece is held at a slight angle, the soldering-iron,—which has been brought to the proper heat, well cleaned and tinned, and charged with solder,—is drawn along the joint at a suitable speed, leaving behind it a perfectly uniform, somewhat raised, bead of solder within the V-shaped recess. While the process of soldering is not precisely difficult, it requires considerable practice to produce a workmanlike result in pipes of all sizes.

When the body and its corresponding foot are soldered, the next process is to form the straight lips required for the mouth of the pipe. To accomplish this, the body is held against a level surface in such a manner that by means of a flat steel tool the sides of the upper lip, which have been indented by the process illustrated in Fig. CCCXIII., are sharply bent mouthward. The body is now adjusted on the flatting-tool, and the upper lip is rubbed down straight, forming a flat slanting portion extending a short distance upward from the lip. This process slightly expands the body at the mouth, caused by bringing the curved portion between the two indentations to a straight line. This in no way impairs the shape of the pipe when finished. The same method is followed in forming the lower lip on the foot. The flatting-tool is a conical piece of hardwood or steel, along which has been planed a flat surface of the proper mouth-width with respect to the circumference at all points along its length. Flatting-tools of all sizes, and with different widths of mouth-flats, are provided for the pipe maker, to suit all sizes and descriptions of labial pipes. The ends of both the body and foot which have been flatted, as above described, are now planed perfectly true, so that when they are brought together the body will stand vertically on its foot. The edges, with the exception of those of the upper and lower lips, are beveled so as to receive the solder-joint. The general appearance of the parts just described is indicated in

the Front View (3) and the Longitudinal Section (4) given in Fig. CCCXVI. The upper part of the pipe-foot, with the lower lip, is shown at A, while the lower part of the body of the pipe, with the upper lip, is shown at B.

The pipe-foot is now ready to receive the languid. One of the pieces, provided in the manner previously described, is taken and cut and filed so as to fit the lower lip in the manner shown at C, in the Top View (1) in Fig. CCCXVI. Being accurately adjusted to leave the proper wind-way (indicated by the broad black line), it is soldered to the foot at D and E. The languid is then cut away so as to follow the remaining portion of the foot,. indicated by the dotted line, and is beveled around its edge until it assumes the finished form shown at F, in the Top View (2). The front edge of the languid is indicated at G, in the Front View (3), and the languid is shown in section at H, in the Longitudinal Section (4). When all the above-described manipulations have been properly carried out, the edges of the body and foot can be accurately brought together and soldered, except, of

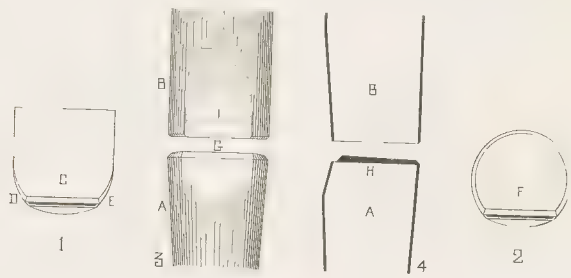


FIG. CCCXVI.

course, where the upper and lower lips meet. The tip of the foot is now coned in and shaped round so as to stand firmly and practically air-tight in the countersunk hole of the wind-chest. Nothing now remains but to cut the opening of the mouth, which is done in the upper lip at the minimum height, as indicated by the dotted line at I, in Fig. CCCXVI. If the pipe is to have ears, they are now soldered on; and after the pipe has been washed so as to remove every trace of the sizing, outside and inside, it is ready for the hands of the voicer.

In the case of displayed pipes, which have mouths of an ornamental character, such as are illustrated in Fig. CCCXVIII., the feet and bodies of the pipes are cut away to receive the lips, which are separate pieces of metal, fitted, and carefully soldered on. Particulars respecting the several treatments will be found in the remarks made with reference to the illustration just alluded to.

Respecting the formation of tapered pipes, bells, tuning-slides, caps, chimneys, and such like adjuncts, much might be written; but enough has been said to give the reader a fair idea of the principal processes of metal labial-pipe formation.

Of all the metal stops which are employed in the tonal appointment of the Organ, those which yield pure organ-tone are unquestionably the most important.

They form the foundation of the complete tonal structure; and upon their tonal character the grandeur, beauty, and utility of the instrument, in which they are introduced, chiefly, if not entirely, depend. The pipes composing these indispensable stops are of what may be designated the normal labial form, having cylindrical bodies open at top, conical feet, and plain straight mouths, to the sides of which are usually added small, projecting strips of metal, called "ears." While the pipes of this class vary in their proportions or scales, they never vary in their general form and construction.

Fig. CCCXVII.

Principals.—Among all the organ-toned stops, the Principals or Open Diapasons stand preëminent. Upon them should be built the tonal structures of the dominating divisions of the Organ. In the Pedal Organ the Principal is of 16 feet pitch, and in the Great Organ it is of 8 feet pitch. From the pipes of the chief Principal of the Great Organ the pipes of all the other organ-toned stops in the manual divisions should be scientifically proportioned both in scale and strength of tone, and especially those octave, mutation, and compound stops which belong to its harmonic series. The Principal, 16 ft., of the Pedal Organ, when of metal, should form the true bass to the Great Organ Principal, 8 ft. In the accompanying illustration, Fig. CCCXVII., are given a Front View and Section of a Principal or Open Diapason pipe. The form of the mouth is that commonly known as the "bay-leaf," from the resemblance of its upper portion to the pointed half of the natural leaf. This form, which is generally preferred by English organ builders for mounted or displayed pipes, is, in our opinion, much more elegant than that generally adopted by the French builders, and which is designated the "French mouth." The bay-leaf mouth is sometimes formed by shaping and indenting the metal of the cylindrical body of the pipe; but the only satisfactory mouth is obtained by soldering in a separate leaf, slightly raised from the surface of the body on edges turned outward to receive it. In Fig. CCCXVIII. are given Front Views and Sections of the principal forms of mouths used at different times and by different builders for their Principals or Open Diapasons, Montres, and other displayed pipe work. At A is shown the bay-leaf mouth in its best treatment, in which both its upper and lower portions are gradually raised from the general surface of the pipe as they sweep from the lips, as clearly indicated in the Section. At B is a modification of

the bay-leaf, the upper portion being defined by straight lines and in no way relieved from the surface of the body of the pipe. This form of mouth has been employed both by English and Continental builders. It is met with in the Organs in the Church of San Petronio, at Bologna, and the Marienkirche, at Lübeck. It also appears in the Organ in Stanford Church, Northamptonshire, built about the beginning of the seventeenth century. It seems to have been a favorite form with the elder Harris, appearing in the Organ he built for Worcester Cathedral. The form is one of those illustrated by Dom Bedos,* shown without ears, as at B. The mouth was sometimes modified by having the lines of its upper portion slightly concave instead of straight, producing an outline exactly contrary to that of the bay-leaf, attended by a somewhat weak effect. In certain old English examples the apex of this form was surmounted by a small circular boss, stamped up from the metal of the body. The so-called French mouth, in what appears to be its most approved form, is shown

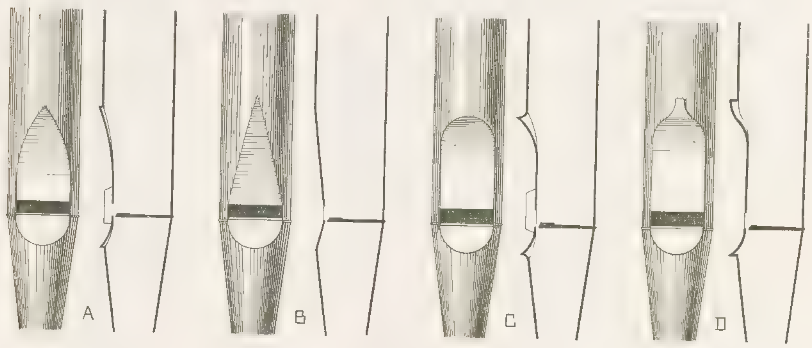


Fig. CCCXVIII.

at C, in which the semicircular parts are curved boldly outward in the manner indicated in the Section. This mouth has always been favored by the French and German builders, and is the one most fully illustrated by Dom Bedos.† When the projections of the semicircular parts are slight, the metal of the body and foot is rounded out, and the edges brought to true lines for the reception of the curved plates forming the upper and lower lips. These are then carefully soldered on. When the projections are considerable, pieces of metal have to be soldered to the edges of the opening in the pipe, and then brought to the desired degree of curvature for the reception of the upper and lower lip-pieces. Both these treatments are illustrated by Dom Bedos, without the addition of ears; indeed the French builders seem to have very rarely used ears for their Montres. This form of mouth, even when it is in no way exaggerated, is not, in our opinion, pleasing, especially when viewed from the side. It seems to cut away too much of the body of the pipe, as will be observed in the Section, while in the front view it looks

* "L'Art du Facteur d'Orgues." Plate LXVIII. † *Ibid.* Plate LXVII.

somewhat heavy compared with the bay-leaf. In the remaining example, at D, we find a modified form of the French mouth, in which the upper part terminates in an ogee treatment having considerable projection. This treatment is also illustrated by Dom Bedos, in Plate LXXVI. of his treatise. Forms very similar to this have been adopted by the old English builders, as in the Organs in Exeter Cathedral and Tewkesbury Abbey. In old Organs both in England and on the Continent, different forms of mouths have been used side by side for the sake of variety; and there is certainly no objection to the adoption of a similar course in modern instruments. The only question that should have any weight in this matter is that relating to tone; and given that all other conditions are similar in two pipes—namely, thickness and quality of metal, scale, width and height of mouth, wind-pressure, and style of voicing—there can be no appreciable difference of tone imparted by the adoption of any two of the artistic treatments of mouth above described. It is true that the French builders, who almost invariably adopt their favorite form of mouth, as shown at C, for their MONTRES, fail to produce a satisfactory "Diapason-tone": but that this failure lies in the peculiar style of their voicing has, we think, been clearly proved by certain distinguished English builders who have used the same form of mouth for their displayed OPEN DIAPASONS, without sacrificing the dignified, rich, and pure, unimitative organ-tone which has always distinguished the old English school of voicing.* The mouths of the tenor

* The following notes from the pen of Professor R. H. M. Bosanquet, a great authority on tonal matters, will be of interest: "If there is any one stop which in itself represents the Organ as a whole it is the OPEN DIAPASON. The pipes of this stop are the typical metal pipes which have always been characteristic of the appearance of the Organ. A single OPEN DIAPASON stop is capable of being used as an Organ of sufficient power for many purposes, though of course without variety. The pipes of this stop are called 'PRINCIPAL' in German, this appellation apparently corresponding to the fact that they are the true and original organ-pipes. The English appellation of 'DIAPASON' has been taken to mean that these are the normal pipes which run through the whole compass. This, however, does not appear to be the actual derivation of the term; originally it is technically applied to the organ-builder's rule, which gives the dimensions of pipes; and it appears that the application to the stop followed on this meaning.

"The scales, character, and voicing of the OPEN DIAPASON vary with fashion, and are different in different countries. We may distinguish three principal types. The old English DIAPASONS of the days before the introduction of Pedal Organs into England were characterized by a rich sweet tone, and were not very powerful. They were generally voiced on a light wind, having a pressure equivalent to that of a column of water of from 2 to 2½ inches. The scale was in some cases very large, as in Green's two OPEN DIAPASONS in the old Organ at St. George's, Windsor; in these the wind was light and the tone very soft. In other cases the scale was smaller and the voicing bolder, as in Father Smith's original DIAPASONS in St. Paul's Cathedral. But on the whole the old English DIAPASONS presented a lovely quality of tone. English travelers of those days, accustomed to these DIAPASONS, usually found foreign Organs harsh, noisy, and uninteresting. And there are many still in England who, while recognizing the necessity of a firmer diapason-tone in view of the introduction of the heavy pedal bass, and the corresponding strengthening of the upper departments of the organ-tone, lament the disappearance of the old diapason-tone. However, it is possible with care to obtain DIAPASONS presenting the sweet characteristics of the old English tone, combined with sufficient fulness and power to form a sound general foundation. And there can be no doubt that this should be one of the chief points to be kept in view in organ design.

"The German DIAPASON was of an entirely different character from the English. The heavy bass of the pedals has been an essential characteristic of the German Organ for at least two or three centuries, or, as it is said, for four. The development of the piercing stops of high pitch was equally general. Thus foundation work of comparatively great power was required to maintain the balance of tone; the ordinary German DIAPASON was very loud, and we may almost say coarse, in its tone when compared with the old English DIAPASON. The German stop was voiced as a rule on from 3½ to 4 inches of wind, not quite twice the pressure used in England.

"The French DIAPASON is a modern variety. It may be described as presenting rather the characteristics of a loud GAMBA than of a DIAPASON. In other words, the tone tends towards a certain quality which may be

and higher pipes of the PRINCIPAL, 8 FT., which are planted on the internal wind-chests, do not require to be ornamental, and are usually formed directly by the flatting-tool.

All the pipes of the PRINCIPALS which occupy positions in the interior of the Organ should be carefully cut to close upon their true speaking lengths, so as to be readily tuned by means of the tuning cones, or by broad tongues cut a very short way down from their top edges, which only require to be curved or bent slightly outward from their openings to bring them into perfect tune. These tongues should only be used for pipes that are considered too large to be conveniently and safely coned. In Fig. CCCXIX. are shown two methods of cutting the tongues. Strong tin-plate tuning-slides, sprung tightly around the tops of the larger pipes are preferable to the tongues, as they never injure the pipe-bodies, and are easy to manipulate in the process of tuning. It is now a very common prac-

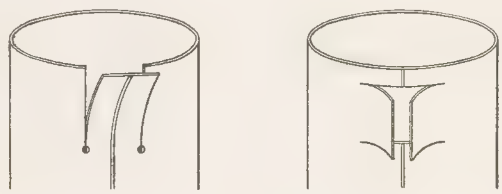


FIG. CCCXIX.

tice with certain builders to slot the tops of PRINCIPAL or DIAPASON pipes, and to tune the pipes by coiling the strips from the slots on the exterior of the pipe-bodies. This is a practice which, so far as pipes intended to produce pure organ-tone are concerned, cannot be too strongly condemned. It is fatal to the production of pure organ-tone, creating in its stead an objectionably dry and horny quality, which fails to blend with the tones of other pipes in the perfect manner the true "English diapason-tone" invariably does.* In all Organ Specifications it should be clearly stipulated that all the PRINCIPALS and other stops producing

described as 'tinny' or metallic, or as approaching to that of a string instrument of rather coarse character. Some modern English builders appear to aim at the same model, and not without success.

"The tone of a DIAPASON must be strong enough to assert itself. It is the foundation of the whole organ-tone. It is the voicer's business to satisfy this condition in conjunction with the requirement that the tone shall be full and of agreeable quality."—Encyclopædia Britannica: Ninth edition. Article "ORGAN."

* A correspondent—a distinguished organist—writing respecting an important Organ recently constructed (1901) by one of the leading English builders, says: "The reeds and action are splendid, but the flue work produces anything but dignified organ-tone. . . . He [the builder] goes in for slotting of pipes, narrow mouths, and high cutting up. In the Organ I am speaking of, though a good price was paid, all the pipes (reeds included) below 4 feet are of zinc. The tone is light and hard. It is impossible to get body in combination; certainly it will not support the FIFTEENTH and MIXTURES. Some of the voicing is very crude. Take the PICCOLO, 2 FT., in the Choir: the higher notes are indistinguishable from the Great FIFTEENTH. It is a useless stop. So is the slotted GAMBA in the Choir, of a hard, horny, thin tone, blending with nothing else." What a falling off these particulars show from the early Organs of the same builder, which are characterized by remarkably fine "diapason-tone," and by the general good quality of their labial work.

organ-tone are to be constructed without slots. This provision is really necessary while the present slotting craze obtains.

The PRINCIPAL pipes which form portions of the external design of an Organ, have frequently to be made much longer than their proper speaking lengths. Large openings have to be cut, close together, down the backs of such pipes until the proper lengths for tuning are obtained. Provided the openings are made as large as possible, the tones of the pipes are not appreciably affected by their over-length. Careful regulation is here of the greatest importance. Every endeavor should be made on the part of the designer to avoid the excessive use of elongated speaking pipes, for they are expensive and have really nothing beyond appearance to recommend them.

Although the scales of organ pipes form the subject of another Chapter, a description of the modes of construction of the pipes now under consideration would be obviously incomplete without some reference to the scales commonly adopted for them. Several scales have been used by different builders for their PRINCIPALS, OPEN DIAPASONS, or MONTRES, of 8 feet pitch, usually dictated by the class, requirements, and general peculiarities of the instruments in which they are placed. These scales commonly range between 7 inches and 5 inches for the internal diameter of the CC pipe. The largest scales seem to have been used by the English builders, but these have, in artistic work, seldom exceeded 6·75 inches. The German builders appear to have fixed the maximum diameter for the CC PRINCIPAL pipe at 6·25 inches. This is the scale of the large OPEN DIAPASON, by Schulze, in the Great division of the Organ in Leeds Parish Church. The tenor C pipe of this magnificent stop measures 3·69 inches in diameter, and the c^1 pipe 2·19 inches. The dimensions, which are as accurate as could be obtained from the pipes *in situ*, indicate that the scale is in the ratio $1:\sqrt{8}$, the half diameter of the CC pipe falling on tenor E. The width of the mouth of the CC pipe is 5¼ inches, cutting off practically six-nineteenths of the circumference of the pipe. The height of the mouth is 1½ inches; and the wind-hole in tip is 1¼ inches in diameter. This stop yields its singularly majestic tone on a wind-pressure of 3¾ inches, showing in its voicing the skill of a master-hand. We know of no organ-toned labial stop which surpasses this in dignity and volume of tone on so moderate a wind-pressure. This pressure must be considered moderate when one bears in mind that in their attempts to obtain dominating "diapason-tone" some English organ builders have resorted to a wind-pressure of 6 inches, completely sacrificing what Professor Bosanquet calls the "lovely quality of tone;" and forgetting his assurance that "it is possible with care to obtain DIAPASONS presenting the sweet characteristics of the old English tone, combined with sufficient fulness and power to form a sound general foundation. And there can be no doubt that this should be one of the chief points to be kept in view in organ design." These words should be lettered in gold and placed on the walls of every voicing-room.

It is unnecessary save in Organs of the first magnitude, in which several unison PRINCIPALS are inserted, to adopt so large a scale as that represented by the CC pipe of 6·25 inches diameter. For large Church Organs it is, as a rule,

undesirable to use a scale exceeding 6 inches for the CC pipe. Schulze advocated the scale of 5·75 inches, in the approved ratio 1 : $\sqrt{8}$, for Church Organs of considerable size. For general adoption in Organs of moderate dimensions, placed in buildings of ordinary size, voiced on wind of about 3½ inches, 5·56 inches will be found ample for the CC pipe; the C pipe being 3·30, and the c^1 pipe 1·96 inches in diameter. For a small Church Organ, voiced on 3½ inches wind, the CC pipe of the PRINCIPAL, 8 FT., need not exceed 5·24 inches in diameter, and the ratio 1 : 2·66 is to be recommended. This scale is also appropriate for a Chamber Organ voiced on wind of 2½ inches. When small scales are used in conjunction with higher wind-pressures, it is most difficult, if not impossible, to secure the sweet, round, and restful tones which are so desirable in a Chamber Organ. In the PRINCIPALS of Chamber Organs we strongly advocate a return to the refined work of the old English masters. As Professor Bosanquet remarks: "The old English DIAPASONS of the days before the introduction of Pedal Organs into England were characterized by a rich sweet tone, and were not very powerful. They were generally voiced on a light wind, having a pressure equivalent to that of a column of water of from 2 to 2½ inches." In the Chamber Organ we constructed several years ago we inserted a PRINCIPALE, 8 FT., having its CC pipe 5·25 inches in diameter, voiced on wind of 2⅜ inches, the tone of which was ample in volume to dominate and sustain that of all the remaining eighteen stops of the instrument, including the five reeds, while it was so pure and smooth that the ear, placed six inches from the mouths of the larger bass pipes, could hardly realize that they were sounded by wind. This stop was universally admired by the most critical musicians.

When two or more PRINCIPALS are inserted in an Organ, they are properly made of different scales. These scales are graduated from that of the MAJOR PRINCIPAL, 8 FT., in the Great Organ, in accordance with the demands of the general tonal scheme of the instrument. It is hardly necessary to remark that each of the unison PRINCIPALS should be voiced to produce a distinctive quality and volume of tone; but no attempt should be made, by slotting or other illegitimate methods, to impart individuality at the sacrifice of pure organ-tone. Mistakes in this direction have been commonly made by English and French organ builders. Indeed, absolutely pure organ-tone has rarely been produced from the French MONTRES.

In the construction of the PRINCIPAL or OPEN DIAPASON pipe the proportions of the mouth are matters of great importance. In alluding to the scale of the fine OPEN DIAPASON, made by Schulze, in the Organ in Leeds Parish Church, we stated the dimensions of the mouth of the CC pipe to be 5¼ inches wide by 1½ inches high. This mouth cuts off six-nineteenths of the circumference of the pipe, as indicated at B in Fig. CCCXX., and, accordingly, its width is slightly in excess of one quarter of the circumference of the pipe. Its height is exactly two-sevenths of its width, or a little less than one-fourth the internal diameter of the pipe. As this stop is a remarkable work of an equally remarkable voicer, these proportions deserve careful consideration, remembering that the wind-pressure is 3¾ inches. For PRINCIPALS, of 8 ft. pitch, of much smaller scales Schulze has

used mouths of larger proportions with much success. These are in some examples equal in width to two-sevenths of the circumference of their respective pipes, as indicated at A. It will never be found necessary to adopt mouths of greater width. For the normal English Open Diapason the width of mouth need rarely exceed one-fourth the circumference of the pipe, as indicated at C; and its height should be one-fourth the internal diameter of the pipe. The height may vary, however, when abnormal wind-pressures are employed. For the pure organ-toned Principal, 8 ft., of the Chamber Organ, when of good scale and voiced on light wind, the height of the mouth may, with advantage to the tone, be reduced to one-fifth the internal diameter of the pipe, or to one-fourth the width of the mouth. With these proportions, a pure and round tone can be procured without any forcing or objectionable windiness.

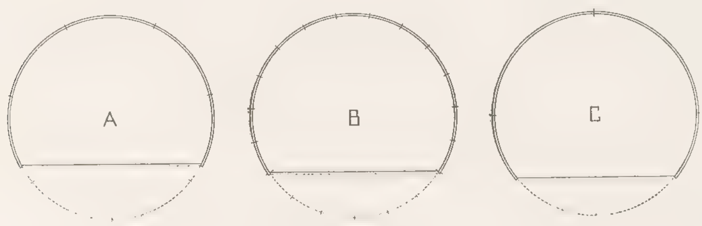


Fig. CCCXX.

The only other matters of importance to be considered in connection with the construction of Principal pipes are the qualities and thickness of the metal employed. As we have discussed the subject of the different metals and alloys to some length in the preceding Chapter, it is only necessary for us to express our opinion respecting those most suitable for the Principals in this place. Generally speaking, any alloy of pure tin and lead having a specific gravity ranging from 7·883 to about 9·060—that is, from an alloy containing 80 per cent tin and 20 per cent lead to one containing 45 per cent tin and 55 per cent lead—may be employed with safety. Unless the pipes are to be displayed, it is not at all necessary to use the high-class alloy containing 90 per cent pure tin. Even in the best work it is not necessary to adopt anything richer than "confluent metal," containing 55 per cent tin and 45 per cent lead. This is richer than the metal used for the inside pipe-work of the celebrated Haarlem Organ, which has stood in perfect condition for more than a century and a half. It is stated to have the specific gravity of 8·864, showing an alloy composed of equal parts of pure tin and lead. We have not a word to say in favor of the use of zinc for the Principals, for we would never willingly approve of it for high-class work.

Almost, if not quite, equal in importance to the quality of the metal is its thickness; for it is quite impossible to obtain a grand pure organ-tone from pipes made of thin metal. It is the necessity for using thick metal, especially for the bass pipes of the Principals, that has led to the frequent adoption of zinc, which is not

only a much cheaper metal but one that, owing to its stiffness, can be used comparatively thin—saving money in both directions. The old English organ builders used fine metal of considerable thickness, notwithstanding the fact that the wind-pressures they adopted were almost invariably under 3 inches. Their pipes were, accordingly, called upon to withstand very weak vibrating air-columns in comparison with those which PRINCIPAL pipes have to withstand under the high-pressure craze of the present day—copiously winded at pressures more than double those favored by the old artists. Notwithstanding this fact, organ builders at the present time commonly make their PRINCIPAL or OPEN DIAPASON pipes of both poorer and thinner metal. The old English builders seem to have used their fine metal about one-twelfth of an inch in thickness for the CC pipes of their OPEN DIAPASONS, graduating it for the pipes below and above that note. The thickness of the metal commonly used by good German builders may be realized from the following weights of the PRINCIPAL, 8 FT., and the stops scaled from it, as given by Töpfer, and rendered in pounds by Mr. Robertson.*

WEIGHT OF STOPS, FORMED OF METAL COMPOSED OF 3 PARTS TIN AND 2 PARTS LEAD. COMPASS 58 NOTES.

NAME OF STOP.	NUMBER OF PIPES.	WEIGHT OF STOP.
PRINCIPAL, 16 FT.	58	992 lbs.
PRINCIPAL, 8 FT.	"	286 "
OCTAVE, 4 FT.	"	62 "
QUINT, 2⅔ FT.	"	24 "
SUPER-OCTAVE, 2 FT.	"	20 "

As a useful table of the minimum thicknesses of metal for pipes throughout eight octaves we give the following from Mr. F. E. Robertson's valuable treatise:

THICKNESSES OF METAL FOR PIPES.

	32 FT.	16 FT.	8 FT.	4 FT.	2 FT.	1 FT.	6 IN.	3 IN.
	IN	IN.	IN.	IN.	IN.	IN.	IN.	IN.
C	0·135	0·103	0·078	0·058	0·045	0·033	0·026	0·020
D	0·129	0·098	0·074	0·056	0·043	0·032	0·025	0·019
E	0·123	0·094	0·071	0·054	0·042	0·031	0·024	0·019
F♯	0·118	0·089	0·068	0·051	0·039	0·030	0·022	0·018
G♯	0·112	0·085	0·065	0·049	0·037	0·029	0·021	—
A♯	0·107	0·083	0·062	0·047	0·035	0·028	0·021	—

* "Die Theorie und Praxis des Orgelbaues," p. 210. "A Practical Treatise on Organ-Building," p. 342.

These thicknesses substantially agree with those we have obtained from the representative works of old organ builders in England and on the Continent, which have stood the test of time. They will be found valuable by those preparing Specifications for first-class pipe-work, as their insertion along with the quality of the metal, subject to the specific gravity test, will secure proper attention on the part of the pipe maker, who will know that his pipes will be liable to rejection if found short of the standards required. It is surprising that so little attention is paid to these important matters by organists and others who undertake to prepare Specifications for large and expensive Organs. The average organ builder will naturally neither suggest nor approve of their insertion in Specifications. It is in such matters, among many others equally important, that the knowledge and services of an experienced Organ Architect are of the greatest value. No Organ of any consequence should be built without the supervision of a qualified expert, engaged by the purchaser to watch his interests and to see every detail of the Specification honestly carried out.

Double Principal is a manual stop of 16 ft. pitch, constructed in every respect similarly to the unison Principals already described. The chief matter to be carefully considered in connection with the Double Principal, when inserted in any manual division, is its relative scale; and with respect to this opinions naturally differ. In deciding its scale one has to bear in mind that the true and fundamental pitch of all the manual divisions of the Organ is 8 feet, and that no stops of pure organ-tone inserted should be calculated to destroy its predominance. Accordingly we are of opinion that in a division in which there is only one Principal, 8 ft., the Double should be made of a smaller scale than the unison, the 8 ft. pipes of each stop being used for comparison. A scale three or four pipes smaller, combined with appropriate voicing and regulating, will be found satisfactory. When two unison Principals are introduced in one division—usually in the Great Organ—the Double Principal may be made of the same scale as the smaller Principal.

The Double Principal, 16 ft., furnishes noble features for the external design of the Organ, its ten largest pipes forming effective semicircular or triangular towers—five alternate pipes in each. When used for this purpose, the pipes should have well-proportioned feet and ornamental mouths of any of the patterns shown in Fig. CCCXVIII. All the remarks we have made respecting the alloys or pipe-metals suitable for the Principal, 8 ft., are equally applicable to the Double Principal, 16 ft. In the construction of the latter stop, which comprises so many large pipes, a considerable temptation obtains to use zinc; and perhaps in cases where economy is an absolute necessity, no reasonable objection can be urged against its adoption for the lowest octave. Let the twelve pipes be made of the best zinc of the proper thicknesses, with spotted-metal languids, lips, and tips; and if the pipes are displayed let them be gilded or decorated in a refined and truly artistic manner. When made of any of the higher-class alloys of tin and lead, all the pipes should have the thicknesses of metal given in the preceding Table.

The Pedal Organ Principal, 16 ft., is usually made of larger scale than that adopted for the manual Major Principal, 8 ft., and, except, perhaps, in complete

Pedal Organs, there can be no serious objection to this practice, provided that the stop is not too powerful in tone. In the properly-appointed Pedal Organ the metal PRINCIPAL, 16 FT., should be scaled and voiced to yield a true bass to the MAJOR PRINCIPAL, 8 FT., of the First or Great Organ: but as in the generality of English and American Organs all ideas of proper tonal appointment so far as the Pedal Organ is concerned are cast aside, the PRINCIPAL, 16 FT., is made of large scale and voiced so as to serve as the bass for the combined unison labial stops of the manual divisions, if not for the Full Organ. It is right to remark that in such instruments the stop is usually of wood. In general form and construction the metal PRINCIPAL, 16 FT., of the Pedal Organ differs in no respect from the DOUBLE PRINCIPAL, 16 FT., of the Great Organ.

The Pedal Organ DOUBLE PRINCIPAL, 32 FT., when of metal, is constructed on the same lines as those above laid down. As might be expected in a stop of this magnitude, the scale varies considerably in different Organs. In the Organ in St. George's Hall, Liverpool, the new lower octave of the metal DOUBLE OPEN DIAPASON, 32 FT., has its CCCC pipe 25 inches in diameter. This octave is of zinc. The CCCC pipe of the SUB-PRINCIPAL, 32 FT., in the celebrated Haarlem Organ, which is of tin, measures only 15 inches in diameter. The corresponding pipe in the Organ in the Monastery Church, at Weingarten, also of tin, is about 15½ inches in diameter. Several metal stops having scales ranging between those above given are to be found in important Organs constructed by different builders. While it is impossible to lay down any rule of universal application for the scaling of this exceptional stop, we can venture to strongly recommend the adoption of the comparatively small scales favored by the German and Dutch masters. If the stop be adequately winded and skilfully voiced, there can be no necessity to exceed the scale of the SUB-PRINCIPAL, 32 FT., in the Haarlem Organ.

OCTAVE and MUTATION STOPS.—All the pure organ-toned octave and mutation stops, properly related to the foundation-work, and which are, or should be, scientifically scaled from the chief PRINCIPAL, have their pipes constructed in precisely the same manner as those of the PRINCIPAL. The most important matter in connection with these harmonic-corroborating or harmonic-creating stops is their relative scaling, and for this unfortunately no rules of universal application have been formulated. This is probably due to the fact that up to the present time few, if any, pipe makers and voicers have devoted sufficient attention to the science of acoustics, so far, at least, as it defines the character, constituents, and phenomena of compound musical sound. Where traditional and rule-of-thumb methods prevail, there is no abiding place for either science or art.

Having in the earlier Chapters of the present treatise spoken at some length on scientific and artistic matters connected with the tonal structure and appointment of the Organ, we may simply remark here that we strongly recommend the adoption of much smaller relative scales than those which have been commonly used by the early German builders for stops higher in pitch than the OCTAVE, and which have been blindly followed by subsequent builders in all other organ-building countries. The wind-pressures and styles of voicing will, of necessity, be potent factors in deciding the scales to be adopted, and these must always be care-

fully considered. Regarding the construction of the pipes of the OCTAVE and the higher mutation stops, it is only necessary to remark that, unless the pipes are mounted in the case-work, the lower and upper lips of their mouths are formed in the ordinary manner by means of the flatting-tool; and that in all cases the relative proportions of their mouths are dictated by the strength of the tones they are required to produce.

COMPOUND STOPS or MIXTURES.—The pipes forming the MIXTURES or the high-pitched harmonic-corroborating stops, which belong to the pure organ-toned series, are constructed in the same manner as the pipes of the mutation stops. As the compound stops are formed of two, three, or more ranks of pipes of high pitch, the sounds of which are introduced in the tonal structure of the Organ to corroborate or create the higher upper partials of the foundation unison tones, produced by the PRINCIPAL, 8 FT., in the manual department and the PRINCIPAL, 16 FT., in the pedal department, the pipes forming their ranks are properly scaled and voiced in due subordination to the scales and voices of the PRINCIPALS. All matters connected with the composition and tonal character of the MIXTURES are treated at length in the Chapter on the Compound Stops of the Organ.

DULCIANA and VOX ANGELICA.—In their most desirable and perfect form, the DULCIANA, 8 FT., and the so-called VOX ANGELICA, 8 FT., are pure organ-toned stops, and may, accordingly, be correctly considered diminutives of the PRINCIPAL, 8 FT., both in scale and tone. The pipes of both these stops have cylindrical bodies, and are constructed in the same fashion as those of the PRINCIPAL. When the larger pipes of the DULCIANA are displayed in the case-work of the Organ, they may have mouths in any of the forms shown in Fig. CCCVIII.; but as their mouths are narrow in comparison with their respective diameters, the forms shown at A and B are to be preferred.

The scale of the DULCIANA varies considerably, being dictated by special circumstances. First, with reference to the scale of the PRINCIPAL or chief unison stop; secondly, by the division of the Organ for which it is designed; and, thirdly, by the strength of tone it is required to yield—either as the softest voice in the Organ, or as a voice intermediate between those of the PRINCIPAL and the VOX ANGELICA, the latter being in this case the softest voice in the instrument. The scale of the normal DULCIANA, 8 FT., commonly ranges between 3·00 inches and 3·65 inches diameter for the CC pipe; but, except in special cases, neither of these scales is to be recommended, for both mark the extreme limits. The most desirable scales under ordinary circumstances range from 3·25 to 3·51 inches diameter for the CC pipe, with the ratio 1 : 2·519, which places the half diameter on the eighteenth step, or F♯. This ratio gives the stop desirable fulness in the treble without, of necessity, increasing its loudness there. The width of the mouth should be one-fifth the circumference of the pipe, while its height is dictated by the wind-pressure and the strength and character of tone desired. For the mouth of the normal DULCIANA pipe an area equal to one-sixth of the transverse area of the body of the pipe has been recommended. The mouths, except, perhaps, in very small pipes, should be furnished with ears of slight projection. Under no consideration should DULCIANA pipes be slotted for tuning purposes; for the slot-

ting destroys the greatest charm of their tone, removing it from pure organ-tone of a clear silvery character to one of a nondescript character. As the DULCIANA in its genuine English form and treatment is worthy of all the care that can be bestowed upon it, we strongly recommend its pipes being furnished with tuning-slides. These will not only prevent the pipes being injured by repeated tuning with the cones, but will secure perfect uniformity in their tonality, their open tops remaining at all times of the correct internal diameters. It is no doubt to avoid the trouble and risk of tuning with the cones that slotting has been so largely resorted to by modern organ builders, who have shown in this and other directions too little appreciation of the subtle refinements of tone. The DULCIANA should be made of the richest spotted or confluent metal.

The pipes of the VOX ANGELICA, 8 FT., differ in form from those of the DULCIANA, 8 FT., only in their scale, while in strength of tone they bear about the same proportion to those of the DULCIANA as the pipes of the DULCIANA do to those of the PRINCIPAL, 8 FT. Such, at least, should be the case, when both a DULCIANA and a VOX ANGELICA are inserted in the same Organ. With the scale in the same ratio as that above recommended for the DULCIANA, the CC pipe of the VOX ANGELICA may have its diameter ranging from 2·30 to 2·79 inches. When the smaller scale is adopted, the mouth may be of the same proportionate width as that recommended for the DULCIANA; but when the larger scale is used, the mouth may be made slightly narrower, say, two-elevenths of the internal circumference of the pipe. The height of the mouth will, as in the case of the DULCIANA, be dictated by the wind-pressure used and the quality of the tone required. On no account should the pipes be slotted. The VOX ANGELICA should be made of tin, its small scale and light weight rendering the adoption of tin a matter of trifling expense.

When in a Chamber Organ, or in the Echo division of a Church or Concert-room instrument, octave, mutation, or compound stops formed of DULCIANA pipes are inserted, they should, to secure proper tonal balance, be made to scales slightly smaller than that adopted for the unison DULCIANA.

The Pedal Organ DULCIANA, 16 FT., is an invaluable and beautiful stop, yet it is surprising how very seldom it is found in the pedal department of important Organs. It is not too much to say that it should find a place in every Organ of any pretensions to completeness or proper tonal appointment. The pipes of this stop, being of small scale and graceful proportions, are admirably adapted for display, especially when they are made of burnished tin. The freedom given to their voices, when the pipes are mounted in the case-work, is of great value, and renders forced voicing altogether unnecessary. The same remarks apply to the DOUBLE DULCIANA, 16 FT., of the manual department. In intonation both these stops, of 16 ft. pitch, are intended to carry down the voice of the DULCIANA, 8 FT.; but in a large instrument, in which both appear, the Pedal Organ stop may with advantage be made to a somewhat larger scale and be voiced to a fuller tone than the manual unison. In form and construction the pipes of the 16 ft. stops differ in no respect from those of the DULCIANA, 8 FT.

DOLCAN.—The pipes forming the DOLCAN, 8 FT., while differing materially in

form from those of the PRINCIPAL and its derivatives, yield a voice on the borderland of pure organ-tone. The proper tone of the DOLCAN is freer or more open than that of the true English DULCIANA, and has, when produced by skilful voicing, a somewhat plaintive singing character which is very pleasing. This tone renders the stop highly suitable for the Chamber Organ and for the accompanimental division in larger instruments. The DOLCAN pipe has a body in the form of an inverted, truncated cone—that is, it is smaller in diameter at its mouth line than at its open top—as shown in Fig. CCCXXI., which represents a tenor C pipe drawn in correct proportions. The scale of the DOLCAN varies according to the volume of tone required; but that which, in the ratio 1 : 2·519, gives the CC pipe a mouth diameter of 3·38 inches and a top diameter of 4·96 inches may be accepted as generally satisfactory. With this scale the tenor C pipe has a mouth diameter of 2·13 and a top diameter of 3·13 inches, and the middle c^1 pipe a mouth diameter of 1·34 and a top diameter of 1·97 inches. These dimensions practically agree with the Roosevelt scale for the DOLCAN, which is before us as we write. The width of the mouth is properly two-ninths of the internal circumference of the pipe at the mouth line; and its height varies from one-fourth to one-third its width, according to the wind-pressure. When a very delicate tone is desired, with a wind of 2½ inches, a mouth of one-fifth the circumference may be adopted, having a height about one-quarter of its width. The languid should be finely nicked in voicing. The DOLCAN should be made of fine quality spotted metal or tin, and of not too great a weight when it is to speak on light wind. The bass octave has sometimes been made of wood, the pipes being square and larger at the top than at the mouth to correspond with the metal pipes, but this practice is not to be recommended. Zinc pipes of the correct form are preferable to those of wood in this case: but in a stop of so delicate an intonation there should be no hesitation in carrying the pipes of fine spotted metal or tin throughout the compass.

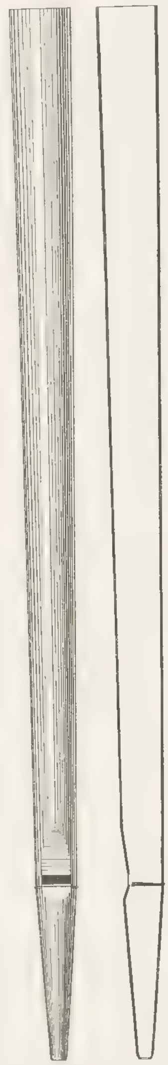


FIG. CCCXXI.

In the Echo division of the Organ in the Parish Church of Leeds is a DOLCE, 8 FT., made by Schulze, the pipes of which are similar in form to those of the DOLCAN. This stop has a delicate tone slightly nasal in character; and being on wind of only 1½ inches is somewhat slow in speech. There is a stop of precisely the same character in the Echo division of the fine Organ built by Schulze, in the Church of St. Bartholomew, Armley, near Leeds.

METAL PIPES OF FLUTE-TONE.

Although all the labial stops of the Organ may be correctly classified under the generic name *flute stops*, there is a certain class of stops to which the name is specifically given by German, English, and American organ builders and experts. The stops commonly included in this class receive the name because their voices partake more or less of that quality of tone which we recognize as flute-tone, represented, in its most perfect development and constitution, by the tone of the orchestral Flute. The French experts seem to commonly use the term in its wider sense. As will be seen on reference to the Chapter on Wood Pipes: and Their Modes of Construction, the more important unimitative and imitative flute-toned stops are formed of wood pipes. The tones of some of these can be successfully imitated by metal pipes; while, on the other hand, there are certain metal flute-toned pipes which have voices that cannot be successfully imitated by wood pipes. These facts clearly show the desirability of including both wood and metal stops in the tonal appointment of the Organ, and of not following the modern practice of ignoring the value of the wood stops, and depending almost entirely on metal stops, constructed largely of zinc to save expense—inferior metal stops. In describing the forms and modes of construction of the metal pipes which properly belong to the flute-work of the Organ, we shall commence with those which yield tones the least removed from pure organ-tone.

FLÛTE À PAVILLON.—This stop, which is called by English builders BELL DIAPASON, is formed of large-scale pipes having cylindrical bodies surmounted by spreading bells, hence the name. The French name is clearly the most appropriate one, because the stop belongs to the flute-work rather than to the principal-work. The main or cylindrical portion of the body of the FLÛTE À PAVILLON pipe is in all essentials similar to that of a large-scale PRINCIPAL pipe, while its upper portion is in the form of a short inverted truncated cone. For facility in tuning, the bell should be attached to a short cylindrical piece fitting closely around the top of the body, its lower edge being cut so as to have a screw-like motion against a small projecting button of solder on the pipe. In tuning the pipe it is only necessary to raise or lower the bell by turning it slightly. The upper portion of the pipe, fitted with its *pavillon* or bell, is shown in Fig. CCCXXII. A peculiar horn-like quality can be imparted to the tone of the FLÛTE À PAVILLON by making its bells longer and of less diameter at top than shown in our illustration, and by cutting a long, narrow slot in each bell. As it is desirable in a loud-toned stop of this class that perfect uniformity of tonal character should obtain throughout its compass, the tuning should be accomplished by the means shown in Fig. CCCXXII., and not by means of tongues cut while slotting the bells. Circular openings can be cut in the bells instead of the long slots, changing slightly the *timbre* of the stop. Bells of moderate diameter are to be preferred, because they allow the pipes to be planted on the wind-chest without requiring an excessive amount of standing room. The mouth of the FLÛTE À PAVILLON pipe is of the same width as that of the MAJOR PRINCIPAL, 8 FT., but it is cut up higher, and may with advantage have its upper lip slightly arched. The height of the

mouth will depend largely on the wind-pressure used and the strength of tone aimed at. In all cases the stop should be copiously winded.

The only FLÛTE À PAVILLON, 8 FT., that we have found in an English Organ is that introduced by Messrs. Gray & Davison, in the Back Great division of the Concert-room Organ in the Town Hall of Leeds. The tenor C pipe of this stop is 3·08 inches in diameter, surmounted by a bell 4½ inches high, with 5 inches diameter at top. The middle c^1 pipe is 1·89 inches in diameter, having a bell 1¾ inches high, with 3 inches diameter at top. The c^2 pipe is 1·15 inches in diameter, having a bell 1 inch high, with 1·75 inches diameter at top. The mouths are about two-sevenths of the circumference of the pipes, and are about one-third of their width in height. The stop is copiously winded on three pressures throughout its compass, and its voice is remarkably powerful.

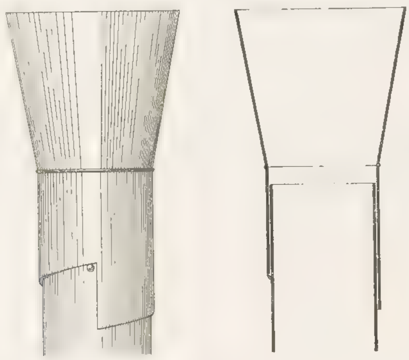


FIG. CCCXXII.

STENTORPHONE, 8 FT.—When properly formed and voiced, the STENTORPHONE is one of the most powerful labial stops in the Organ. It is of larger scale than the MAJOR PRINCIPAL and its pipes are made of metal of great thickness, so as to withstand the vibrations caused by the high-pressure wind on which it is voiced. This pressure ranges from seven to ten inches. The pipes have plain, cylindrical bodies, and are constructed in all respects like those of the PRINCIPAL, 8 FT. A suitable scale for the STENTORPHONE, 8 FT., in the ratio 1 : 2·519, gives the CC pipe 7·02 inches diameter and the tenor C pipe 4·42 inches diameter. The mouths should be two-sevenths the internal circumference of the pipes in width, and their height should not be less than one-third their width. This stop strictly belongs to the flute-work.

SERAPHONPFEIFE.—The stop to which this name has been given is capable of yielding a more powerful voice than the STENTORPHONE. It was invented by Mr. G. F. Weigle, and first introduced in the large Organ in the City Church of Wertheim, Baden, constructed by Messrs. G. F. Steinmeyer & Co. The pipes which form this stop are of large scale and have two mouths, formed in the usual man-

ner, and placed as close together as practicable, as shown in the Front View and Transverse Section of the lower portion of a pipe given in Fig. CCCXXIII. The large lineal measurement of the combined mouths—about four-tenths of the circumference of the pipe—gives a powerful intonation. The quality of the tone depends on the scale of the pipe, the height and shape of the upper lips of its mouths, the pressure of the wind on which it speaks, and the manner of voicing.

A stop formed of pipes of so powerful an intonation would be extremely valuable in the Solo division of a large Concert-room Organ, where its prominent voice would add volume and solidity to the high-pressure reed-work there introduced. Voiced so as to yield as closely as possible a pure flute-tone, the SERAPHONPFEIFE, 8 FT., would be an important addition to the Great division of a large Organ. The flat treatment of the mouths of the SERAPHONPFEIFE gives the stop, in all its tonal developments, a great advantage over the high-pressure labial stops invented by Mr. W. T. F. Weigle, Organ Builder, of Stuttgart, in which the pipes have semicircular mouths, rendering regularity in voicing an extremely difficult and uncertain operation. In the year 1893 Mr. Weigle took out patents in Germany and England, and in 1894 he patented his invention in the United States.* In the Specification of the American Patent the inventor says :

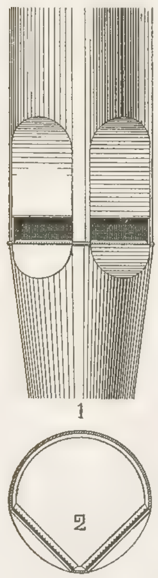


FIG. CCCXXIII.

"I, Wilhelm Theodor Friedrich Weigle, organ builder, a subject of the King of Württemberg, residing at Stuttgart, in the Kingdom of Württemberg, Germany, have invented a new and useful Improvement in Organ Pipes. . . My invention relates to labial organ pipes, the object being to confer upon large Church and Concert Organs, especially as regards their solo stops, that strength of tone and quality of timbre which is expected from such instruments in very large spaces. . .

"Hitherto it has been sought to obtain the required strength of tone in large instruments by providing them with from eighty to one hundred and twenty stops, that is to say, by increasing the number of pipes as much as possible. Instruments so constructed, however, require a large amount of space, and the tone-effects obtained bear no manner of proportion to the expense incurred in their erection. Moreover, the characteristic timbre of the stops is too weak to produce a fine effect in a large building with such Organs. Nor is the required strength of tone obtained by re-inforcing the stops by combining with them other, even if similar, stops, on the contrary the effect is disadvantageous inasmuch as the characteristic timbre is thereby concealed and rendered undecided.

"The tone of an Organ is no doubt strengthened to some extent by increasing the number of stops, that is to say, the number of pipes to each note, because the effect of the simultaneous sounding of a number of pipes is to set a larger volume of air in sympathetic vibration, so that the tone acts upon the ear more strongly, although its amplitude (intensity) is

* "Organ-pipe." United States Letters Patent, No. 520,344, dated May 22, 1894. German Patent, No. 74,674, dated July 30, 1893. English Patent, No. 17,718, dated Sept. 20, 1893.

thereby in no way increased. This method of re-inforcing the tone does not, however, suffice for large spaces and is, as has already been remarked, very expensive. The immediate question then, one which several organ builders had attempted to solve, was how to increase, by the use of air at a pressure considerably higher than that usually employed, the tone of single pipes or stops. This has up to now [1894] only been successfully accomplished in the reed stops of the Organ. As regards the labial pipes, on the other hand, it has not been possible, in their present form, to feed them with air at a pressure much above that usually employed, since, when the pressure is increased, the tone loses its precision, and becomes in the highest degree unmusical and disagreeable, or the pipes may even refuse to speak at all.

"By means of the new labial organ pipe it is possible to produce a labial-pipe tone of extraordinarily beautiful timbre, and with a tone-strength of any desired intensity. In order to obtain any desired strength of tone from this new high-pressure air labial pipe, it is only necessary to increase the pressure of the air to a corresponding extent. By this means it is possible to construct instruments for large buildings with half the number of stops, and so with half the number of pipes but with equal, indeed greater strength and fulness of tone. This is done in the case, for instance, of an instrument which, to be of adequate power, would require to be built with about a hundred stops, by constructing it with about forty stops of the ordinary kind, and in addition with about ten high-pressure stops."

We have given Mr. Weigle's special pleading in full, because it presents all that can be advanced in favor of "intensity," "power," "fulness," and "strength" of tone; in short, in favor of loudness and its necessary attendant coarseness, and against variety and refinement of tone—those artistic properties for which we have pleaded throughout the present treatise. It is folly to suppose that an Organ of

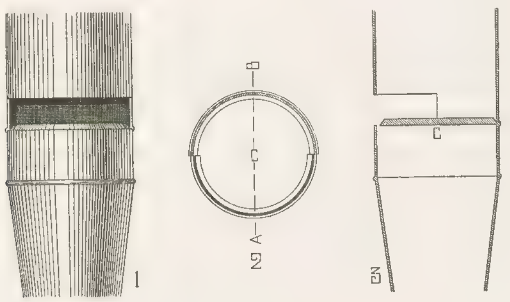


Fig. CCCXXIV.

fifty stops appointed on the Weigle system could be made to bear comparison on any artistic or musical grounds, or, indeed, on any ground save that of simple loudness, with such an instrument as the Concert Organ in St. George's Hall, Liverpool, with its hundred beautiful speaking stops. But in considering Mr. Weigle's words we must not forget that he is the inventor of loud-voiced, high-pressure pipes, and that he is a German organ builder saturated with the old traditions of his art. We do not want to-day any more blatant voices in the Organ; on the contrary, we want more refinement and more variety of tone, combined with greater

flexibility and powers of expression throughout the tonal forces of the instrument.

Notwithstanding what we have just said, the present Chapter would be incomplete without a description of the Weigle high-pressure pipe for which the patents were granted. In the accompanying illustration, Fig. CCCXXIV., are given a Front View, a Transverse Section, and a Longitudinal Section of the mouth portion of the patent pipe, clearly indicating all the peculiarities of its construction. The upper and lower lips and the wind-way of the mouth are semicircular, extending half the circumference of the body of the pipe. The form of the languid is shown in the Transverse Section, 2, one-half being soldered to the body of the pipe, while the other half is reduced in radius in order to form the wind-way, indicated by the thick black line. The Longitudinal Section, 3, cut on the line A—B, and the Front View, 1, show the treatment of the parallel-lipped, semicircular mouth. The construction of this form of mouth is attended with considerable labor and care; and it is difficult to realize what, beyond an undesirable strength and coarseness of voice, is secured by so difficult a treatment—a treatment which will certainly never come into general use or be recognized by artistic organ builders. The Weigle patent high-pressure pipes may be considered as half-way toward steam whistles.

Fig. CCCXXV.

Spitzflöte.—The pipes which form the stop usually called the Spitzflöte, or, as rendered in English, the Spire Flute, and in French, Flûte à Pointe or Flûte à Fuseau, have their bodies in the form of a slender, truncated cone open at top. The scale of the stop differs widely according to the office it fulfils in the tonal appointment of the Organ. On the one hand it is introduced because its voice possesses good mixing and filling-up properties, while on the other hand it is properly valued on account of the special quality of its flute-tone. For the former purpose, the stop is usually made to a large scale, while for the production of a refined flute-tone it is made to a comparatively small scale. Then, apart from its general scale, the relative proportion which the top diameter of the Spitzflöte pipe bears to its larger diameter at the mouth line varies in different examples. In those made by English builders the upper diameter varies between one-half and three-quarters of the lower diameter, while the German usage makes the top only about one-third of the diameter at the mouth line. The different proportions exercise a great influence on the tone of the pipe. The dimensions given by Töpfer, and apparently used by Friedrich Haas, the builder of the Lucerne Organ, are practically as follows: For the CC pipe 4·60 inches diameter at the mouth, and 1·50 inches diameter

at top. These dimensions, with the scale in the ratio 1 : 2·519, give 2·90 inches diameter at the mouth and 0·95 inch diameter at the top for the tenor C pipe. This is unquestionably a good medium scale, and one suitable for the production of the characteristic bright flute-tone of the true SPITZFLÖTE. The proportions of the tenor C pipe, according to the above dimensions, are shown in Fig. CCCXXV. The mouth may be made one-fourth or two-ninths of the larger circumference of the pipe; and its height may vary from one-fourth to one-third of its width, according to the wind-pressure and the volume and quality of the tone desired. The nicking of the lower lip and languid should be moderately fine; but this also depends on the wind-pressure and supply, and the tone aimed at. On no account should the pipes be slotted for tuning purposes; and the greatest care should be taken in cutting them to pitch, so as to require the slightest application of the tuning-cones. The pipes are best made of tin or confluent metal of medium thickness. The SPITZFLÖTE is made of 8 feet, 4 feet, and 2 feet pitch; and there is also a SPITZQUINT, 2⅔ FT.

ROHRFLÖTE or FLÛTE À CHEMINÉE.—The German ROHRFLÖTE and the French FLÛTE À CHEMINÉE, in their representative forms, are large-scale metal stops, usually of 8 ft. and 4 ft. pitch, formed of labial pipes having cylindrical bodies covered with sliding metal caps, to the top of which are soldered small open cylindrical tubes or "chimneys." The pipes forming these stops are accordingly classified as half-covered or half-stopped, to distinguish them from the covered or stopped pipes of the GEDECKT and BOURDON. The form and correct proportions of a middle c^1 FLÛTE À CHEMINÉE pipe are given in Fig. CCCXXVI. Diagram 1 is a Front View and Diagram 2 is a Longitudinal Section of the pipe. These have been accurately drawn from a pipe in our possession made by a distinguished French organ builder. The several dimensions of this pipe are as follows: Internal diameter of body 1·62 inches; length of body from lower lip 10¾ inches; internal diameter of chimney 0·28 inch; length of chimney 3 inches; width of mouth 1⅜

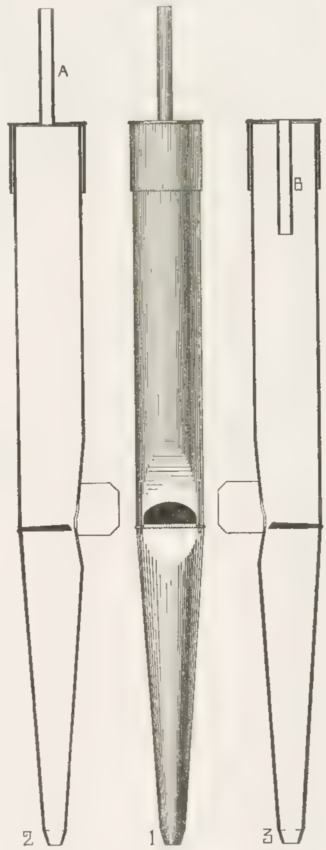


FIG. CCCXXVI.

inches; height of mouth in center 5/8 inch; projection of the ears 1 3/8 inches; and wind-hole in foot 1/4 inch. Both the languid and lower lip have twenty-two bold nicks. This pipe is roughly tuned by the sliding cap, and then accurately tuned by bending the large ears inward or outward. The latter method of tuning is not always followed.

The distinctive feature of the ROHRFLÖTE pipe is its perforated cap, to which is soldered the open tube or chimney; the perforation, prolonged by the chimney, imparting a certain clearness and brightness to the voice of the pipe. As both the relative diameter and length of the chimney affect the tone, these dimensions vary considerably in examples made by different builders. The larger the diameter, the more the tone approaches that of an open pipe. The diameter of the chimney varies in ordinary examples from one-sixth to one-third of the diameter of the body, while the length of the chimney varies from one-fourth to one-half the speaking length of the body of the pipe.* According to Dom Bedos, larger chimneys were sometimes used†: but as large ones destroy the desirable and distinctive tonal character of the pipes, their diameter should never exceed one-fourth that of their respective pipes; nor should their length exceed one-half the speaking lengths of the bodies of their respective pipes. In the large representation of the FLÛTE À CHEMINÉE given by Dom Bedos, the chimney is exactly one-third the diameter and one-half the length of the body of the pipe.

The tonal peculiarities of the ROHRFLÖTE, and the acoustical problem involved, appear to have exercised the enquiring minds of organ builders and others. Professor Helmholtz, however, touches the matter very slightly in his important treatise, "Die Lehre von den Tonempfindungen." He only says: "Narrow stopped pipes let the Twelfth be very distinctly heard at the same time with the prime tone, and have hence been called *Quintaten* (quintam tenentes). When these pipes are strongly blown, they also give the fifth partial, or higher major Third, very distinctly. Another variety of quality is produced by the ROHRFLÖTE. Here a tube, open at both ends, is inserted in the cover of a stopped pipe, and in the examples I examined its length was that of an open pipe giving the fifth partial tone of the prime tone of the stopped pipe. The fifth partial tone is thus proportionately stronger than the rather weak third partial on these pipes, and the quality of tone becomes peculiarly bright." Here the Professor leaves the subject. It was, accordingly, left to Dr. Robert Gerhardt to dive deeply into the acoustical problem presented by the ROHRFLÖTE, and show the scientific world what the pro-

* "Zur Länge des Röhrchens die halbe Länge der Pfeife und zur Weite 1/4 des Umfanges der Pfeife. Es wird sich also der Querschnitt des Röhrchens zum Querschnitt der Pfeife verhalten wie 1 : 16."—Die Theorie und Praxis des Orgelbaues.

† "On observera que les proportions des tuyaux à cheminée sont absolument les mêmes que celles des tuyaux bouchés; ainsi il est aisé de mettre à cheminée tous ceux-ci; on n'a qu'à y ajouter la cheminée sur le couvercle. Elle doit être d'autant plus haute qu'on la fait grosse; & plus elle est menue, plus elle doit être courte. Les plus grosses ont la moitié du diametre du corps du tuyau. En ce cas elles doivent être presqu'aussi hautes que le corps de leurs tuyaux. Il y a des Facteurs qui leur donnent le quart ou le demiquart seulement de son diametre, elles sont alors beaucoup plus courtes à proportion. Plus la cheminée est grosse & haute, plus l'harmonie approche de celle d'un tuyau ouvert; & plus elle est courte & menue, plus l'harmonie du tuyau approche de celle d'un tuyau bouché. Ainsi dans le choix des tuyaux bouchés ou ouverts, on a égard à l'effet qu'on veut qu'ils fassent."—L'Art du Facteur d'Orgues (original edition), Part I., page 42.

found mathematical mind could do in the matter. This he did, greatly to his own satisfaction, in his treatise entitled, "Die Rohrflöte, ein Pfeifenregister der Orgel." * We cannot attempt in these pages to give any digest of so profound a treatise, so shall simply note the proportions presented by the two representations of the ROHRFLÖTE given in the same. In one of these, the diameter of the chimney is equal to one-fourth that of the body, and its length is equal to two-fifths of the speaking length of the pipe. In the other drawing, the diameter of the chimney is slightly more than half that of the body, and its length is about three-fourths the length of the body. In this latter case the pipe is practically an open one.

It is somewhat remarkable that neither in this special treatise on the ROHRFLÖTE, nor in any work on organ matters known to us, is any mention made of the fact that it is unnecessary, so far as the characteristic tone of the pipe is concerned, to have the chimney occupying the usual external position on the cap, as shown in Diagrams 1 and 2 in Fig. CCCXXVI. The chimney produces precisely the same tonal effect when attached to the inside of the cap and hangs within the body of the pipe, as indicated at B in the Longitudinal Section 3. We have before us as we write two ROHRFLÖTE pipes identical in all respects save in the positions of their chimneys: one having the chimney as at A, and the other having it as at B, in Fig. CCCXXVI. Notwithstanding these apparently contradictory positions, the tones yielded by the two pipes are identical. It is difficult to account for this similarity of tone, and it adds much to the acoustical problem connected with the speech of the ROHRFLÖTE. One thing is certain, it is not the simple elongation, in a direct line, of the column of air within the pipe that affects the tone: some other force is at work which no one, to our knowledge, has attempted to explain. The inside position of the chimney affords it great protection from injury.

In the ROHRFLÖTE, 8 FT., it is not necessary to carry the pipes with chimneys below tenor C. The bass octave may be formed of covered pipes of metal or wood,—preferably the former,—voiced to carry down the normal tone of the stop as closely as possible. In the stop of 4 ft. pitch the top octave should be formed of open flute-toned pipes.

The scale of the ROHRFLÖTE, 8 FT., varies considerably in different old examples. Large scales have been employed by both German and French builders, but these are neither necessary nor desirable in a properly-balanced, modern Organ. A good medium scale, in the ratio $1 : \sqrt{8}$, gives the tenor C pipe a diameter of 2·66 inches; the middle c^1 pipe a diameter of 1·58 inches; and the c^2 pipe a diameter of 0·94 inch. This scale is almost identical with that indicated by the French pipe of which the dimensions have been given. Let the chimneys be one-fourth the diameter of the respective bodies, and from one-third to one-half the speaking length of the bodies, according to the quality of tone desired. The proportionate lengths of the chimneys may decrease as the lengths of the bodies increase. No rule of universal application can be given in a matter where art and taste should rule supreme. The proper form of the mouth is accurately represented in Fig. CCCXXVI.

* "Nova Acta der Ksl. Leop.-Carol.-Deutschen Akademie der Naturforscher."—Band XLVII. Nr. 1. Halle, 1884.

DOPPELROHRFLÖTE.—Although it appears that the DOPPELROHRFLÖTE has in the majority of cases been made of wood, the pipes of the treble octaves—from c^1 to c^4—may with advantage be formed of metal. As the name implies, the pipes have two mouths; and it is only in this respect that they differ in form and construction from the pipes of the ROHRFLÖTE just described. Instead of having metal caps with chimneys, we would suggest the adoption of perforated wood stoppers. It is not easy to tune the DOPPELROHRFLÖTE pipes by means of large projecting ears, and as it is difficult to accurately tune by means of the metal caps, it becomes advisable to employ stoppers that are easily manipulated. Allowing that the wood stoppers are made of the proper lengths, and are perforated with holes correctly graduated, they will influence the tone in precisely the same manner as the metal chimneys do. Should a very full and filling-up tone be desired, the scale may be slightly increased beyond that given for the ROHRFLÖTE. The mouths should each be one-fifth of the circumference of the pipe, and have arched upper lips of the same form and proportionate height as shown for the ROHRFLÖTE, Fig. CCCXXVI. The pipes of the tenor octave may be of wood, with double mouths and perforated stoppers, while those of the bass octave (when the stop is of 8 feet pitch) may be of large-scale wood pipes, wholly stopped, and having single mouths.

GEDECKT, STOPPED DIAPASON, or BOURDON.—In England the name STOPPED DIAPASON is commonly understood to mean a manual, covered stop composed of wood pipes, notwithstanding the fact that many fine examples have been made of metal, with the bass octave only of wood pipes. In Germany, while wood pipes are much in favor for the normal GEDECKT, metal pipes are frequently employed for the treble octaves of the stop. A remarkable instance of the use of metal pipes throughout a GEDECKT of 16 feet tone is furnished by the BOURDON in the Great division of the Organ in the Cathedral of St. Bavon, at Haarlem, constructed in the year 1738. In France the term BOURDON is applied to covered stops of 16 ft., 8 ft., and 4 ft. pitch, composed chiefly or entirely of metal pipes of large scale. This was the practice when Dom Bedos wrote.*

The metal pipes of the French BOURDONS are of large scale, and are formed of a rich alloy of considerable thickness. They are usually covered with sliding lids or caps of the same material, lined with thin leather, or sliding against paper wound around the tops of the pipes. The mouth of the true BOURDON pipe is about one-fourth or two-sevenths of the internal circumference of the pipe in width,

* "*Le Bourdon de 8 pieds*, qui est un 4 pieds bouché, qu'on appelle aussi *petit Bourdon*, ou, *Bourdon de 4 pieds*, à l'unisson du 8 pieds ouvert. C'est un Jeu de grosse taille, de toute l'étendue du Clavier, dont on fait la premiere octave de la basse en bois, & le reste en étoffe, tout bouché ou à cheminée. On en met un semblable au Positif. On l'emploie encore à la Pédale dans les petites Orgues lorsqu'il n'y a pas assez de place pour une Pédale de Flûte de 8 pieds ouverte. Il faut ajouter qu'il n'y a point d'Orgue où il n'y ait au moins un petit Bourdon pareil, pour servir de fondement à l'harmonie; sans quoi l'Orgue parleroit une octave plus haut; ce qui feroit un *aigu* désagréable.

"*Le Bourdon de* 16 *pieds* est un 8 pieds bouché qui parle à l'unisson du 16 pieds ouvert. On fait les deux premieres octaves en bois, & le reste en étoffe. Ce Jeu doit être de grosse taille, comme tous les Bourdons, pour faire un bon effet. Il est toujours de toute l'étendue du Clavier, si la place le permet. Dans les grandes Orgues, on met quelquefois un Bourdon de 16 pieds dans le Positif; on peut en mettre un à la Pédale, si la place ne permet pas d'y loger un 16 pieds ouvert."—L'Art du Facteur d'Orgues (original edition), part I., page 45.

and about two-fifths of its own width in height; but the proportions of the mouth, as well as the form of its upper lip, differ according to the character and volume of the tone desired. For the production of a full, humming flute-tone, proper for the true BOURDON, a mouth one-third its width in height, and having a straight or very slightly arched upper lip, is to be preferred: but in these matters the supply and pressure of the pipe-wind are controlling factors. The scale according to Dom Bedos gives the tenor C pipe a circumference of 10·37 inches, or a diameter of 3·30 inches; and as his scale is evidently based on the common ratio 1 : $\sqrt{8}$, the middle c^1 pipe will have a circumference of 6·17 inches, or a diameter of 1·96 inches, and the c^2 pipe will have a circumference of 3·66 inches, or a diameter of 1·16 inches. The minimum scale advocated by this old authority gives the tenor C pipe a diameter of 2·93 inches. A tenor C pipe, according to the larger scale, is represented in Fig. CCCXXVII.

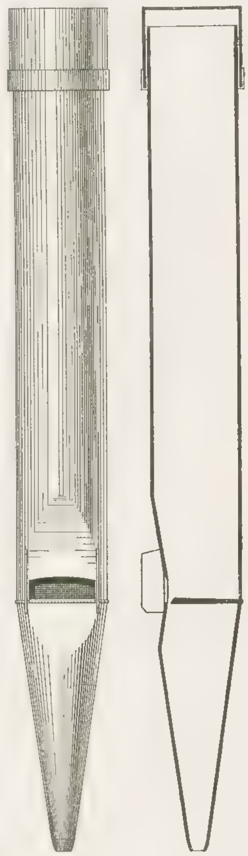


FIG. CCCXXVII.

The fine BOURDON, 16 FT., in the Great division of the Organ in the Town Hall of Manchester, constructed by A. Cavaillé-Coll, has its two lowest octaves of wood. The CCC pipe is 6½ inches wide by 8 inches deep. The C pipe,—the largest of metal,—which speaks on the middle c^1 key, is 3·37 inches in diameter, having a mouth 2½ inches wide by $1\frac{1}{16}$ inches high, with upper lips slightly arched, flanked with ears 2½ inches long and 1 inch projection. This pipe and the eleven above it are closed with metal caps; while the upper portion of the stop is formed of FLÛTE À CHEMINÉE pipes. The pipe which speaks on the c^2 key is 2·25 inches in diameter, having a mouth 1⅝ inches wide by $\frac{11}{16}$ inch high, with upper lip slightly arched. The speaking length of its body is 10¼ inches; and its chimney is 5 inches long by 0·56 inch in diameter.* All the metal pipes are made of a high-class alloy, and very weighty.

The scales mentioned above are certainly too large for the pipes of a GEDECKT or STOPPED DIAPASON made and voiced on English traditional lines. When the stop is carried in metal pipes down to tenor C, the scale, in the ratio 1 : $\sqrt{8}$, which gives that pipe a diameter of 2·55 inches, the middle c^1 pipe a diameter of 1·51 inches, and the c^2 pipe a diameter of 0·90 inch, can be safely

* We obtained these measurements as accurately as practicable from the pipes in situ.

adopted. The mouths should be one-fourth the internal diameter of the pipes in width; and in height they will vary from one-fourth to one-half their width according to the pressure and supply of the pipe-wind, and the power and quality of the tone required. The mouths should have ears of moderate size, unless they are designed for close tuning, when they should be large and flexible like those of the French FLÛTE À CHEMINÉE. The pipes may be covered with metal caps in the French fashion, or have turned wooden stoppers covered with thick soft leather. Carefully fitted stoppers of the finest quality of cork (such as is selected for champagne corks) may be used for the smaller pipes, say from middle c^1. The most satisfactory stopper, however, is that made of perfectly-seasoned mahogany, turned, and cased around the portion which enters the pipe with a layer of the finest soft cork, varying from about $\frac{1}{16}$ inch to ¼ inch in thickness, according to the size of the wood core. Such a stopper, when properly fitted to its pipe, does not require the addition of leather, and leaves nothing to be desired. It has no tendency to fall in the pipe or become unsound; and when coated with pure tallow it moves easily in the process of tuning. In the accompanying illustration, Fig. CCCXXVIII., is shown the upper portion of a metal GEDECKT pipe with a Longitudinal Section of the stopper last described.

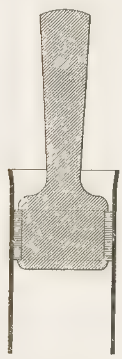


FIG. CCCXXVIII.

In the German GEDECKT, 8 FT., the metal pipes do not, as a general rule, descend below middle c^1. This appears to have been the practice followed by E. Schulze, as exemplified by the GEDECKTS in his remarkable Organ in St. Peter's Church, at Hindley, Lancashire. The scales of these stops vary. The GEDECKT, 8 FT., in the Great Organ has a c^1 pipe of 1·50 inches diameter, with a mouth 1⅛ inches in width and $\frac{9}{16}$ inch in height; and the GEDECKT, 8 FT., in the Swell Organ has a c^1 pipe of 1·31 inches diameter, with a mouth-width equal to one-fourth the internal circumference of the pipe, cut up equal to three-fifths of its width.* The wind-pressure is 3½ inches in both these manual divisions.

All covered metal pipes should be made of the best spotted metal, and of sufficient thickness to withstand the pressure of the stoppers for any length of time. The stoppers should not fit too tightly; it is sufficient that they are air-tight and have no tendency to drop in the pipes. They should move smoothly in the process of tuning.

LIEBLICHGEDECKT.—The true German LIEBLICHGEDECKT is simply a small-scale GEDECKT, of 16 ft., 8 ft., or 4 ft. pitch, formed of wood, wood and metal, or altogether of metal. The stop of 4 ft. pitch, which is frequently labeled LIEBLICHFLÖTE, should be formed entirely of metal pipes, the top octave of which should be open. The pipes of the LIEBLICHGEDECKT are voiced to yield a bright and singu-

* The bass and tenor octaves of both these stops are formed of wood pipes. The scale of the CC pipe of the GEDECKT in the Great is 2·87 inches by 3·87 inches, having a mouth 2 inches high. The CC pipe of the stop in the Swell measures 2·12 inches by 3 inches, having a mouth 2¼ inches high, or slightly more than its width. Moderate scales, high mouths, and copious winding, are characteristics of the true German GEDECKTS, both of wood and metal.

larly pleasing quality of flute-tone, hence its name, which may be rendered *Lovely-toned Stopped Flute.* The tone is best produced on low pressures of wind, ranging from 1½ to 2½ inches. Both the LIEBLICHGEDECKT, 8 FT., and the LIEBLICHFLÖTE in the Choir division of the Organ in St. Peter's Church, Hindley, are on wind of only 1⅞ inches, while the same stops in the Echo division of the Organ in Leeds Parish Church speak on wind of 1½ inches. All these beautiful stops are by Edmund Schulze. A satisfactory scale for the LIEBLICHGEDECKT, 8 FT., is that which, in the ratio 1 : 2·519, gives the tenor C pipe an internal diameter of 1·97 inches, the c^1 pipe a diameter of 1·24 inches, and the c^2 pipe a diameter of 0·78 inch. The same scale, in the ratio 1 : $\sqrt{8}$, gives the following internal diameters: C, 1·96 inches; c^1, 1·16 inches; and c^2, 0·69 inch. The scale of Schulze's LIEBLICHGEDECKT, 8 FT., in the Hindley Organ, gives the middle c^1 pipe—the lowest pipe in metal—a diameter of 1·19 inches. The mouth is one-fourth the internal diameter of the pipe, and its arched upper lip is ½ inch in height in the center. The LIEBLICHFLÖTE, 4 FT., in the same Organ, has the same scale and mouth treatment. Larger scales are favored by some German pipe makers. A favorite scale, in the ratio 1 : 2·519, gives the CC pipe (metal) a diameter of 3·51 inches; the C pipe a diameter of 2·21 inches, and the c^1 pipe a diameter of 1·39. For the Chamber Organ, in which extreme delicacy of tone is required, a small scale may be adopted. We recommend the scale, in the ratio 1 : 2·66, which gives the tenor C pipe of the LIEBLICHGEDECKT, 8 FT., an internal diameter of 1·81 inches, and the c^1 pipe a diameter of 1·11 inches. The same scale may be adopted for the LIEBLICHFLÖTE, 4 FT., in which no wood pipes need be introduced. With a wind-pressure of 1½ inches, the mouths of the pipes should be one-fifth the circumference and about one-half their width in height, having slightly arched upper lips. The greatest care should be bestowed on the scaling and voicing of the LIEBLICHGEDECKTS, for of all the unimitative flute-toned stops they most fully repay the labor expended on them.

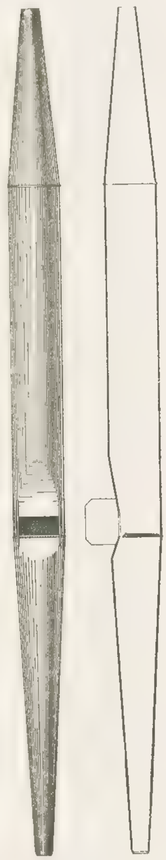


FIG. CCCXXIX.

SPINDELFLÖTE or SPINDLE FLUTE.—The SPINDELFLÖTE is a metal stop of 8 ft., 4 ft., or 2 ft., which derives its name from the peculiar form of its pipes. The SPINDELFLÖTE pipe differs from the SPITZFLÖTE pipe inasmuch as, instead of tapering from the mouth line to the top, only the upper portion of its body is conical. The form of the pipe is shown in Fig. CCCXXIX. The scales adopted by the German builders were usually small; and the size of the opening at the top of the conical portion of the pipe varied in different examples according to the quality of tone

required. When the opening is very small, the tone produced is between those of the SPITZFLÖTE and the ROHRFLÖTE, while, on account of the small scale, it should be more delicate than either. The mouth of the SPINDELFLÖTE should be one-fifth the circumference of the pipe, and about one-half its width in height. The height, however, may be increased or diminished according to the wind-pressure and the character and strength of tone desired. When carefully made and voiced, the SPINDELFLÖTE, 4 FT., is admirably suited for the Chamber Organ. As the opening at the top of the pipe must on no account be altered, the tuning has to be accomplished by means of the large ears, as in the case of certain other forms of pipes. Another German stop, called SCHWIEGEL, was usually formed of metal pipes having cylindrical bodies surmounted by truncated cones. Owing to the trouble attending the formation of pipes of the class just described, they have practically ceased to appear in modern Organs, the simpler pipes of the SPITZFLÖTE being adopted instead, attended, however, with a decidedly different intonation.*

FLÛTE HARMONIQUE or HARMONIC FLUTE.—The FLÛTE HARMONIQUE was invented by MM. Cavaillé-Coll, and first introduced by them in the Grand Organ constructed, in 1841, for the Abbey Church of Saint-Denis, near Paris. The stop derives its name from the fact that the pipes forming the higher portion of its compass are so constructed and voiced as to yield their first harmonic upper partial tones instead of the tones which normally belong to their full lengths. The pipes which form the harmonic portion of the HARMONIC FLUTE, 8 FT., usually commence on the note f^1 or g^1, although they are occasionally, and desirably, carried down to middle c^1. In the HARMONIC FLUTE, 4 FT., and the HARMONIC PICCOLO, 2 FT., the harmonic pipes are, of course, carried one and two octaves lower than the notes above mentioned. Open pipes of wood or metal, of the normal speaking lengths, are used for the lower portion of the stops of 8 ft. and 4 ft. pitch. In this place, however, we have to deal only with the form and construction of the harmonic pipes. In selecting a stop for illustration and description we cannot do better than take the FLÛTE HARMONIQUE, 8 FT., in the Great division of the Concert-room Organ erected by Cavaillé-Coll in the Town Hall of Manchester. The lowest harmonic pipe of this stop is g^1, shown in correct proportions in the accompanying illustration, Fig. CCCXXX. The pipe is 2·37 inches in diameter and 29½ inches in length from its mouth-line. At the distance of 13 inches from that line a hole ⅛ inch in diameter is drilled, as shown in the illustration. The mouth of the pipe is 1¾ inches in width and $\frac{11}{16}$ inch in height, having a straight upper lip. Through the agency of the perforation in the body, which prevents the formation of a node in the middle of the internal column of air, and by the pipe being slightly overblown, a note is produced which is about the octave of that which

* In "An Explanation of the Organ Stops," by Carl Locher, translated by Agnes Schauenburg (London, 1888), is given an illustration of a metal pipe with a cylindrical body surmounted by a truncated cone having a very small orifice at top. This is described as a SPITZFLÖTE in the following words: "SPITZFLÖTE (spire or taper flute) is a much-used open metal stop with conical tops. Its tone is somewhat brighter than that of FLÛTE D'AMOUR, and is often used as sharpening stop for several mellow 8 ft. stops on the upper manuals. It appears more frequently as an 8 ft. than as a 4 ft. tone." The illustration here alluded to is evidently incorrect, being that of a SPINDELFLÖTE pipe as clearly described and illustrated by Seidel, and as shown in our illustration, Fig. CCCXXIX.

normally belongs to a pipe of the full length of 29½ inches. In addition to its high pitch the note has a peculiar quality and volume, owing largely to the scale of the pipe, which would be excessive in a pipe about half its length, yielding a note of similar pitch under ordinary conditions. The quality or *timbre* of the note is also due to the prominence of certain upper partial tones obtained by skilful voicing. The bass of the FLÛTE HARMONIQUE, 8 FT., in the above-mentioned Organ is formed of open wood pipes, the CC one of which has the scale of 5·00 inches by 6·50 inches. The open metal, non-harmonic pipe—middle c^1—has a diameter of 2·75 inches and a speaking length of 22 inches, belonging to a very large scale.

FIG. CCCXXX.

Certain organ builders prefer to construct the HARMONIC FLUTE entirely of metal. This appears to be the commendable practice of the distinguished builders, MM. Casavant Frères, of St. Hyacinthe, P. Q., Canada, who have furnished the following particulars. The pipes of the HARMONIC FLUTE, 8 FT., are open and non-harmonic from CC to e^1=29 notes; and the larger of these, when circumstances permit, are advantageously employed as displayed pipes. The CC pipe is 5·37 inches in diameter internally, having a mouth one-fourth the circumference of the pipe, and slightly more than one-fourth its width in height, having a straight upper lip. The tenor C pipe is 3·26 inches in diameter, having a mouth of the proportions just given. The diameters are approximately in the ratio 1 : 2·66. The harmonic pipes commence on f^1. This pipe is 2·03 inches in diameter and, of course, about twice the ordinary speaking length. It is pierced with a hole about $\frac{1}{16}$ inch in diameter. The general rule for determining the position of this hole in harmonic pipes is as follows: Divide the body of the pipe—the full length of which is calculated to yield the note an octave below that which it is destined to yield when rendered harmonic—into nine equal parts, and make the perforation at the height of four of these parts above the languid. The size of the hole should be carefully graduated in the pipes forming the harmonic portion of the stop; and their size varies in different stops according to the strength and quality of the tone desired. As MM. Casavant correctly state, a larger hole than that above named changes the tone somewhat and permits its strength to be increased. The mouths of the harmonic pipes are one-fourth the circumference of their respective pipes, and one-third of their respective widths in height. The nicking of their languids and lower lips is preferably made deep, about eighteen nicks being made in the c^2 pipe, and in the others in proportion.

In the HARMONIC FLUTE, 4 FT., the open non-harmonic pipes extend on the

clavier from CC to B = 24 notes. Their mouths have a width equal to one-fourth of the circumference of their respective pipes, and a height between one-fourth and one-third of their width. Their upper lips are slightly arched. The double-length harmonic pipes commence on the middle c[1] note of the clavier. The height of the mouth of the pipe at this note is one-third its width, and the height is gradually reduced to one-fourth as the pipes decrease in size. The particulars above given are for stops voiced on the ordinary wind-pressure of 3½ inches.

FIG. CCCXXXI.

ZAUBERFLÖTE.—This valuable addition to the voices of the Organ is due to the genius of the late Mr. William Thynne, Organ Builder, of London. The following particulars are derived from the last ZAUBERFLÖTE, 4 FT., voiced by this great artist in tone-production, and placed in the Organ in St. John's Church, Richmond, Surrey. The stop is formed of wood and metal, and its unique and characteristic feature obtains in the fact that from tenor C to the top note of its compass the pipes are stopped and harmonic, speaking the first possible upper partial tone—the Twelfth—of the ground tone belonging to their speaking length. The reader may be here reminded that the first harmonic yielded by a stopped pipe is the second upper partial tone yielded by an open pipe capable of yielding the same ground or prime tone under the ordinary conditions. The octave of the stop from CC to BB is formed of open wood pipes, the scale of the CC pipe being 2·13 inches by 2·81 inches. The mouth of this pipe is ⅝ inch in height, and has a straight upper lip, about ⅛ inch thick, and slightly rounded. The wind-way is narrow; and both cap and block have twenty nicks cut in a vertical direction. The cap is set ⅛ inch below the edge of the block. The mouth is of the ordinary form, sloped externally, and without applied ears. The cap is hollowed and cut to a sharp edge at the wind-way. From tenor C to E = 5 notes, the pipes are of wood, stopped, and harmonic. The scale of the C pipe is 2·13 inches by 2·75 inches; and its length from its lower lip, including sufficient hold for the stopper, is 2 feet 9½ inches. It is perforated with a hole, $\frac{1}{16}$ inch in diameter, 19¼ inches above the lower lip. In all cases the holes are made as small as possible, being just sufficient to prevent the pipes from speaking their ground tone. The mouth is of the same form as in the open pipes, and has a straight upper lip about $\frac{1}{10}$ inch thick, cut up $\frac{7}{16}$ inch. The cap, which is set flush with the edge of the block, is sunk on the inside to form the wind-way, and is sloped externally, to correspond with the mouth, leaving ⅛ inch at the wind-way. This treatment, which was used by Schulze in the wood pipes of his PRINCIPALS, 8 FT., allows a free current of air to approach the mouth from below. In the ZAUBERFLÖTE this sloping of the cap is slightly rounded, and not straight like that of the upper lip of the

mouth. Both the block and cap have twenty-eight fine nicks, cut vertically as in the open pipes. The feet of all the wood pipes are of metal so that exact regulation may be readily accomplished.

We now come to the metal portion of the stop, which commences on tenor F and extends to the top note. The scale of this portion is best given at the middle c^1 pipe. The internal diameter of this pipe is 1·91 inches, and its length is 17 inches from the lower lip, allowing about 1¼ inches for the stopper. The harmonic perforation is about $\frac{1}{16}$ inch in diameter, and is situated at the distance of 9 inches above the languid. The exact proportions of this pipe are shown in Fig. CCCXXXI. The width of the mouth is $1\frac{5}{16}$ inches, and its height is a fraction more than one-fourth of its width. The upper lip is straight; and the mouth has small ears. The wind-way is of medium size and has twenty-six fine nicks. All the pipes have cork stoppers mounted on wooden handles.

The Zauberflöte was made by Mr. Thynne of both 8 ft. and 4 ft. pitch. When of the former pitch, the bass octave was formed of stopped wood pipes, voiced to carry down the characteristic tone of the stop as closely as possible. The true tone, however, obtains only in the harmonic range of the stop.

Slotted Flute.—The Slotted Flute is a new stop of 4 ft. pitch, producing a tone which differs from the tones yielded by all the commonly-made flute stops, open, covered, or half-covered. It is still in a tentative state, but deserves to be carefully developed so as to form a special family. The form of the middle c^1 pipe is given in Fig. CCCXXXII. The chief peculiarity consists in its being covered with a sliding cap, closed at top, and pierced on its side with an oblong opening or slot, as shown. The pipe is tuned by the raising or lowering of the cap, which is made sufficiently long to have a firm hold of the pipe-body below the slot. A satisfactory scale for this stop, in the ratio 1 : 2·519, gives the middle c^1 pipe a diameter of 1·24 inches, and the tenor C pipe a diameter of 1·97 inches. On this latter pipe the slotting is commenced, and is carried to the top note. The mouth is in width equal to two-ninths of the circumference of the pipe, and its height is one-third its width. The upper lip is slightly arched, as shown, and curved outward to a small extent. The wind-way is moderately fine, and in the c^1 pipe is finished with seventeen small nicks. The slot may be varied in its length and width according to the strength and quality of the tone desired; but one measuring 1¼ inches in length by ⅜ inch in width, cut ½ inch down from the stopped end of the cap, may be accepted as suitable for the c^1 pipe. All these dimensions obtain in our illustration. A variation of the tone is produced by substituting a circular perforation ½ inch in diameter, cut ¾ inch down

Fig. CCCXXXII.

from the stopped end. In a complete stop the bass octave should be formed of large-scale open metal or wood pipes, voiced to yield a decided flute-tone, carrying down as closely as possible the tone of the slotted pipes of the tenor octave.

OCARINA.—The OCARINA is a modern, open metal stop of 4 ft. pitch, which produces a hollow fluty tone, closely resembling that of the terra cotta instruments of the same name.* The special pipes of this uncommon stop commence at tenor C and extend to the top note. The form and exact proportions of the treble c^2 pipe are shown in the accompanying illustration, Fig. CCCXXXIII. The speaking length of this pipe is 6⅛ inches, while the cylindrical portion of its body has the large scale of 1·13 inches diameter. The bell is 3 inches long, and its upper open end has a diameter of 1·69 inches. The pipe is tuned by means of the strip cut from the slot in the bell, as shown. The mouth is ⅞ inch in width, and about one-fourth of its width in height. The upper lip is straight; and the languid is finely nicked. These particulars are derived from the stop in the Choir division of the Organ in the Church of St. Mary, East Parade, Bradford, Yorkshire, built by M. C. Anneessens. When this stop is carried down to CC, the bass octave may be made of either open or stopped metal pipes, as may be found most suitable for carrying down the peculiar tone of the special pipes. This stop should be of tin.

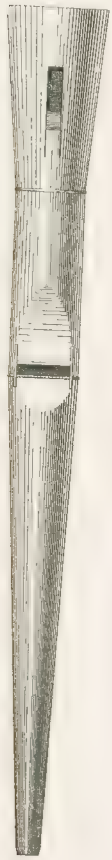


FIG. CCCXXXIII.

QUINTATEN.—The QUINTATEN of 8 ft. pitch is, in its most satisfactory form, a covered metal stop of rather large scale, the pipes of which are voiced to yield their first upper partial tone—the Twelfth—in addition to their proper ground-tone, hence the name of the stop (from *quintam tenens*). The form and correct proportions of a middle c^1 pipe of full scale, derived from an eminently satisfactory example, are as follows: The body of the pipe is cylindrical, with a speaking length of 11 inches and an internal diameter of 1·29 inches. It is covered with a sliding cap of 1½ inches long, made air-tight by a lining of soft paper. The pipe is tuned by means of this cap. The width of the mouth is two-ninths of the circumference of the pipe, and is $\frac{5}{16}$ inch in height. The upper lip is straight, and the languid and upper lip have seventeen bold nicks. The pipes forming the lowest octave of the stop from which the above particulars have been derived have mouths furnished with projecting ears carrying cylindrical wood harmonic-bridges. The diameter of the CC pipe is 3·25 inches and the speaking

* "OCARINE (*It.*) A series of seven musical instruments [of different pitches] made of terra cotta pierced with small holes [and having whistle-like mouthpieces], invented by a company of performers calling themselves the Mountaineers of the Apennines. With these instruments, which are of a soft and sweet, yet 'traveling' quality of tone, operatic melodies with simply-harmonised accompaniments were given." "A Dictionary of Musical Terms," by Stainer and Barrett.

length is 3 feet 10 inches. The ratio of the stop is 1 : 2·519. The mouth of the CC pipe is $2\frac{3}{16}$ inches in width by $\frac{11}{16}$ inch in height. The upper lip is straight; and the languid and lower lip are boldly nicked. The stop is voiced on wind of $3\frac{1}{3}$ inches.

ZARTFLÖTE.—Of all the metal stops yielding tones more or less resembling those of the QUINTATENS, the stop now under consideration may be pronounced the most beautiful. The ZARTFLÖTE in its covered form was invented by the distinguished English artist, Mr. John W. Whiteley, in the year 1896. The pipes forming this stop are of small scale, fully stopped, and have narrow mouths furnished with cylindrical harmonic-bridges. In Fig. CCCXXXIV. are given a Front View and Longitudinal Section of the chief portions of the tenor C pipe of the ZARTFLÖTE, 8 FT., or the largest pipe of the ZARTFLÖTE, 4 FT. The harmonic-bridge is of aluminium tubing, held, at a considerable distance from the lower lip of the mouth, between strong ears shaped as shown in the Section. The bridge is secured in position by projections, punched from the ears, which enter the tube at both ends. The scale of the stop, in the slow ratio 1 : 2·13, gives the C (2 ft.) pipe a diameter of 1·24 inches; the c^1 pipe a diameter of 0·85 inch; the c^2 pipe a diameter of 0·58 inch; and the c^3 pipe a diameter of 0·40 inch. The mouths are unusually small, being about two-elevenths of the circumferences of their respective pipes. It will probably be found desirable to increase the widths of the mouths in the two higher octaves to one-fifth the circumferences of the pipes. The harmonic-bridges vary in diameter from 0·25 inch at tenor C (2 ft. pipe) to 0·06 at the c^4 pipe. It is only necessary to have six different sizes, changing them at about equal intervals in the compass. The stoppers are of soft cork rings glued to turned wood handles, as indicated in the Longitudinal Section. In voicing the pipes a greater number of nicks are placed on the languids than on the lower lips. For instance, in the tenor C pipe the languid has eight nicks while the lower lip has only five. The nicks are very small and cleanly cut. In describing this ZARTFLÖTE, its inventor says: "This stop is a modification of the QUINTATEN, with every suggestion of tonal coarseness removed. It bears the same relation to the ordinary QUINTATEN that a very refined DULCIANA or SALICIONAL does to an OPEN DIAPASON,

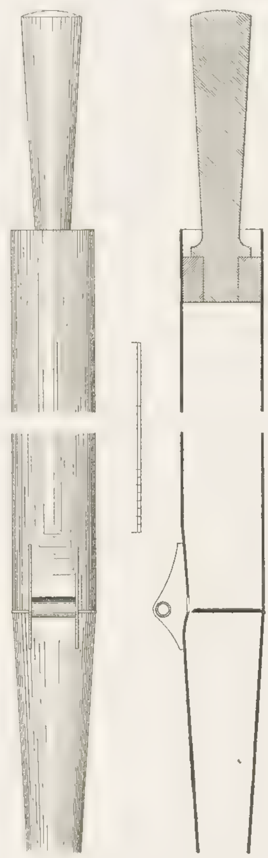


FIG. CCCXXXIV.

the result being a light and bright flute-tone, with sufficient reedy quality to give it a distinctive character."

METAL PIPES OF STRING-TONE.

Of all the classes of metal labial stops which go to complete the tonal forces of the Organ, there is no one which has been developed during late times to so remarkable a state of perfection as the class yielding imitative string-tone. The most artistic results have been achieved by English artists, among whose names those of William Thynne and John W. Whiteley will always deserve honorable mention in the history of organ-building. While such is the case, it is but right to remark that in the stop known as the GAMBA the German builders pointed the way to subsequent developments; and that in the appliance designated *frein harmonique*, invented by MM. Gavioli et Cie., the French showed an awakening interest in the production of imitative string-tone.*

GEIGENPRINCIPAL.—The GEIGENPRINCIPAL, 8 FT., as properly constructed and voiced by the German organ builders, yields a rich organ-tone in which a stringy quality of comparatively little prominence asserts itself, imparting a tonal-coloring which contrasts in an effective manner with the full-bodied pure organ-tone of the English OPEN DIAPASON. The GEIGENPRINCIPAL is a favorite stop of the German builders, appearing in the majority of their important Organs in either the second or third manual divisions. In the hands of English organ builders this stop, either under its proper name or the English equivalent VIOLIN DIAPASON, has rarely assumed its true dignity. The best examples known to us are those introduced in the Organs constructed by Messrs. T. C. Lewis and Co., where they invariably appear in the Swell division.

The GEIGENPRINCIPAL, 8 FT., is formed of cylindrical pipes of medium scale, preferably of fine spotted metal, having mouths one-fourth their circumference, and between one-fourth and one-third of their own width in height. The best tonal results are obtained when the mouths are furnished with the harmonic-bridge; but care must be taken to prevent too much interference with the foundation-tone, otherwise the stop will lose its characteristic dignity. Under no circumstances should its pipes be slotted. The best scale for the normal GEIGENPRINCIPAL, 8 FT., gives the following diameters in inches: CC, 4·66; C, 2·78; c^1, 1·65; c^2, 0·98; c^3, 0·58; c^4, 0·35. This is practically the scale advocated by Edmund Schulze, in the ratio $1 : \sqrt{8}$. Should a fuller tone be desired in the higher octaves, the scale may be in the ratio 1 : 2·66, starting with the diameter of 4·62 inches for the CC pipe.

GEIGENOCTAVE.—This stop, of 4 ft. pitch, is, as its name implies, the true Octave of the GEIGENPRINCIPAL, 8 FT. Its pipes are of the same form as those of the unison stop above described. As the GEIGENOCTAVE (very commonly termed

*A stop formed of small-scale tin pipes fitted with the *frein harmonique* was exhibited by M. Henri Zimmermann, of Paris, in the Paris Exposition of 1878. Seeing it there, the author of the present treatise employed M. Zimmermann to construct a VIOLA D'AMORE for his Chamber Organ, thereby introducing the *frein harmonique* into English organ-building for the first time in the same year.

GEIGENPRINCIPAL, 4 FT.) should never be introduced in the absence of the GEIGENPRINCIPAL, 8 FT., its scale should be subordinate to that of the unison stop: accordingly, it may be made two pipes smaller. The GEIGENOCTAVE should be voiced so as to blend perfectly with the GEIGENPRINCIPAL, 8 FT., enriching without disturbing the unison tone. In our opinion it is undesirable to introduce the octave stop, except, perhaps, in Organs of the first magnitude.

SALICIONAL.—Secondary in importance to the GEIGENPRINCIPAL is the true SALICIONAL. Properly scaled and voiced, it yields a string-tone of unimitative, but singularly delicate character. It may be said, when voiced by a master, to be one of the most beautiful stops in the Organ. As made by different builders, in different countries, the stop varies considerably in its tonal coloring, the variation appearing chiefly in the amount of string-tone it yields in combination with its subdued organ-tone. The SALICIONAL, 8 FT., is made to several medium scales; but probably that commonly adopted by the late Mr. F. Haas is the most suitable. This scale, in the ratio 1 : 2·66, gives the CC pipe a diameter of 3·21 inches; the C pipe a diameter of 1·97 inches; and the c^1 pipe a diameter of 1·20 inches. The mouths should be one-fifth the circumference of their respective pipes, although they are sometimes made wider; their heights being dictated by the quality of tone desired, the wind-pressure, and, accordingly, the strength of voice. Both larger and smaller scales have been used, but, in our opinion, that of the CC pipe should never exceed 3·48 inches in diameter, the ratio of the scale being 1 : 2·66. A good small scale, in the same ratio, gives the CC pipe a diameter of 3·08 inches, and the C pipe a diameter of 1·89 inches. The SALICIONAL pipe is properly made with a cylindrical body; but a slender, conical form has sometimes been adopted, as shown in the only drawing of the pipe given in "Die Theorie und Praxis des Orgelbaues" (Plate III., Fig. 16). It is occasionally slotted, but as this treatment imparts a horny tonality, we cannot recommend its adoption. The cylindrical pipe should be provided with a tuning-slide at top in preference to resorting to coning. The mouth of the SALICIONAL pipe, either cylindrical or conical, is usually fitted with some form of harmonic attachment calculated to aid the development of the delicate string-tone characteristic of the stop. A curved beard of pipe-metal, soldered to the foot of the pipe, and extending upward between the ears, is a favorite form of this attachment. A representative example of this is shown in the Front View and Longitudinal Section given in Fig. CCCXXXV., which have been carefully drawn from a middle c^1 SALICIONAL pipe made by the late Mr. Hilborne L. Roosevelt. The triangular and wavy form of the beard gives the air free access below the mouth. The diameter of the pipe is 1·25 inches, indicating a medium scale. The mouth is unusually large for a SALICIONAL pipe, having a width equal to one-fourth the circumference of the same. When a very delicate quality of tone is desired, in which the string character is not required to be pronounced, the mouth, one-fifth the circumference of the pipe, may be treated in the manner shown in the Front View and Longitudinal Section given in Fig. CCCXXXVI. It will be seen that the beard and ears are formed of one strip of metal, bent, and soldered (at the ears only) to the pipe-body. This treatment appears in connection with the GEIGENPRINCIPAL pipe illustrated in "Die Theorie

und Praxis des Orgelbaues" (Plate III., Fig. 6). While we have not met with this treatment in an actual GEIGENPRINCIPAL, we are of opinion that it is well adapted to impart the tonal quality so desirable in that effective stop. In voicing, both the languids and lower lips of all the pipes are closely and cleanly nicked, as indicated in Fig. CCCXXXVI. The pipes should be made of tin or a high-class alloy; but they do not require to be very weighty, especially if they are voiced on wind of a low pressure. The SALICIONAL is made of both 8 ft. and 16 ft. pitch; sometimes it also, and properly, appears of 4 ft. pitch under the diminutive SALICET. For further remarks on this subject see Chapter XIII.

ÆOLINE.—This stop, properly of 8 ft. pitch, in its most approved labial form may be considered an ECHO SALICIONAL. It is formed of small-scale cylindrical pipes, preferably of tin, the mouths of which are furnished with ears and small, adjustable curved beards after the fashion shown in Fig. CCCXXXV. The latter greatly aid the production of the delicate string-tone which is the desirable char-

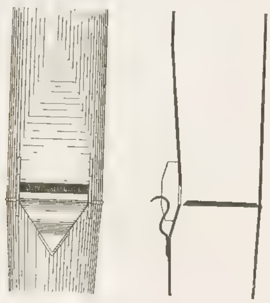


FIG. CCCXXXV.

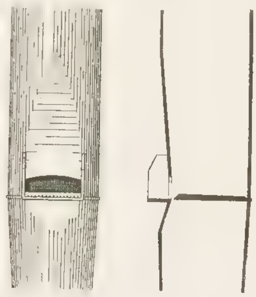


FIG. CCCXXXVI.

acteristic of the stop. A suitable scale for this stop, in the ratio 1 : 2·519, gives the CC pipe a diameter of 2·51 inches; the C pipe a diameter of 1·54 inches; and the c[1] pipe a diameter of 0·94 inches. The mouths to be one-fifth or two-ninths the circumference of their respective pipes, and kept as low as practicable, consistent with the quality and strength of the tone required. The ÆOLINE is peculiarly suitable for the Chamber Organ.

VIOLA DA GAMBA.—Apparently the first real attempt made by the old German organ builders to produce imitative string-tone showed itself in the stop called by them VIOLA DA GAMBA. In this they strove to reproduce, as closely as the then state of their art permitted, the tones of the orchestral Viola da Gamba—an instrument held in the highest estimation in Germany and elsewhere during the seventeenth and eighteenth centuries, and for which Johann Sebastian Bach wrote several beautiful compositions. The pipes of the stop, as originally made, were cylindrical and of medium scale; and they were invariably slow of speech, so much so as to be almost valueless when used alone or for rapid passages. This class of stop has been commonly distinguished among English organ builders by the name

German GAMBA; and while it is more stringy than the GEIGENPRINCIPAL, its tone cannot be said to be satisfactory from an imitative point of view. Later essays were more successful, when small-scale pipes were used and greater promptness of speech secured. A radical departure (from the old slow-speaking, cylindrical German GAMBA) in quest of imitative string-tone was made when the stop designated GLOCKENGAMBA or BELL GAMBA was devised and introduced in the Organ. As the voicing of this stop was improved and its tone became more imitative, the above names, which simply alluded to the form of its pipes, gave way to the more desirable and expressive name VIOLA DA GAMBA. This form of stop is now very rarely made, first because its pipes are troublesome to construct properly; and, secondly, because a much better tonal result can be readily obtained from pipes of simpler form. The shape of the old VIOLA DA GAMBA pipe is shown in the accompanying illustration, Fig. CCCXXXVII. Its body is conical, surmounted by a bell; and as this shape does not permit of tuning at the top of the pipe, the mouth is furnished with large, projecting, flexible ears, by means of which the accurate tuning is accomplished. The pipes have to be cut as closely as practicable to their true speaking lengths, so as to render the shading of their mouths by the ears a small matter. The pipes as above described have very rarely been carried below tenor C. The scale employed varies in different examples; but the following dimensions may be accepted as proper for the middle c^1 pipe: Diameter at mouth 1·39 inches; diameter at junction of bell 0·76 inch; diameter at top of bell 1·27 inches; length of bell 4 inches; and length of body about 21·5 inches, or as long as is called for by the musical pitch of the stop, the wind-pressure, and any other controlling factor. The mouth to be one-fourth the larger circumference of the pipe, and one-fourth its own width in height.

FIG. CCCXXXVII.

The characteristic tone of the old Viola da Gamba can be closely imitated by small-scale cylindrical or conical pipes, preferably of tin, the mouths of which are small, and furnished with small ears and slender harmonic-bridges.* The VIOLE DE GAMBE, 8 FT., in the Swell division of the Organ in the Town Hall of Manchester, constructed by A. Cavaillé-Coll, is of small-scale, cylindrical tin pipes, the mouths of which, devoid of ears, are fitted with a simple form of *frein harmonique*, as shown in Fig. CCCXXXVIII. The *frein* here consists of a narrow strip of tin, the ends of which are bent at right angles and soldered to the sides of the pipe. This method is not to be recommended,

* The author has had opportunities of studying the tone of the true Viola da Gamba, and does not hesitate to make this assertion.

as it renders an absolutely correct initial adjustment a matter of considerable difficulty, and any subsequent easy adjustment practically impossible. The *frein* is omitted in several of the higher pipes. The tone of the stop is pleasing, but lacking in brilliancy and crispness. A better result is obtained by applying the *frein* in the manner shown in Fig. CCCXXXIX. The narrow strip or plate is here inserted in oblique saw-cuts made in the ears, rendering a certain amount of adjustment possible so far as its distance from the mouth is concerned.

It is extremely difficult to convey in writing any clear idea of the tone of the true Viola da Gamba; but as some guide to the pipe voicer we may say that it is considerably thinner and less pungent than the tone of the Violoncello, of which latter instrument the Viola da Gamba was the precursor. Perhaps the best advice we can give the pipe voicer of to-day, is to imitate as closely as practicable the tone of the orchestral Viola (Viola da Braccio), played at medium strength. This treat-

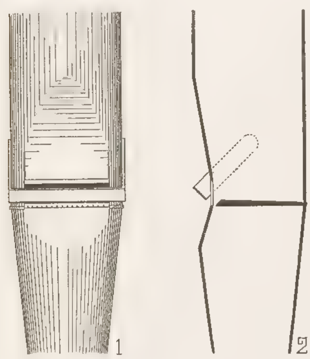


Fig. CCCXXXVIII.

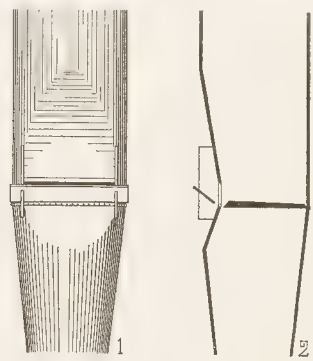


Fig. CCCXXXIX.

ment will place the tone of the Viola da Gamba in proper subordination to that of the imitative Violoncello. The Viola da Gamba when made and voiced by a master hand is a most desirable stop for the true Chamber Organ, in which refinement and delicacy of tone are essential conditions.

Viola d'Amore.—The orchestral Viola d'Amore—now practically an obsolete instrument—is rather larger than the Viola now in use. It is strung with seven catgut stopped strings, and with several metal sympathetic strings, which pass through the bridge and under the finger-board. These metal strings are tuned to the gut strings, and, accordingly, vibrate sympathetically with them, producing a compound tone "full of sweetness and mystery." It is this character of tone that the organ-pipe voicer has to strive to produce. The Viola d'Amore of the Organ is properly formed of small-scale, cylindrical tin pipes, having mouths three-thirteenths their circumference, and about one-fourth their own width in height, furnished either with the *frein harmonique* or some other description of

harmonic-bridge. In Fig. CCCXL. are given a Front View and Longitudinal Section of the mouth portion of the tenor C pipe of the VIOLA D'AMORE, 8 FT., made by Henri Zimmermann, of Paris, for the author's Chamber Organ. The dimensions of this pipe are as follows: Diameter 1·75 inches; width of mouth 1·24 inches; and height of mouth 0·33 inch; the ratio of the scale being 1:2·519. The *frein harmonique* (system Gavioli), which is adjusted to the mouth in the manner shown, consists of the thin brass plate A, 1·44 inches long and 0·44 inch wide, supported by the strip B, attached to the foot of the pipe and adjusted to the mouth by means of the two tapped-wires and leather buttons C and D. The strip B is forked and slotted, as indicated in the Front View, to allow the plate A to be raised or lowered, while the strip, acting as a spring, is moved to or from the pipe under the control of the button D. The inclination of the plate or *frein* A can be readily altered by bending the curved portion of the strip. By these means every

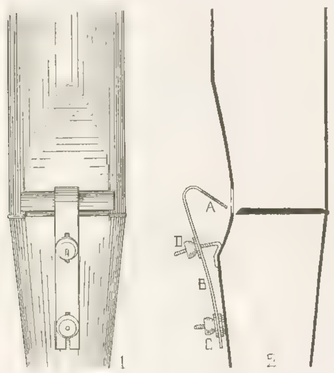


FIG. CCCXL.

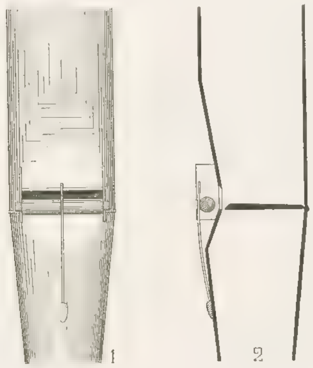


FIG. CCCXLI.

requisite adjustment can be executed with facility: and the *frein* can be removed should the mouth require manipulation at any time. The top of the pipe has a tuning-slide in which is a slot 1¼ inches long by $\frac{9}{16}$ inch wide.

Although the pipes of the VIOLA D'AMORE may be said to be invariably cylindrical in modern work, we are strongly of opinion that a more satisfactory tone could be obtained from conical pipes of small scale, unslotted, and having their mouths furnished with small cylindrical harmonic-bridges, fitted so as to be removable, in the manner shown in Fig. CCCXLI. The advantage of movable bridges was fully realized by the late Mr. Henry Willis, for we find all the GAMBAS in the Organ in Glasgow Cathedral furnished with them—those of the larger pipes being of turned hardwood and those of the smaller pipes of wire of different gauges. All are held in their positions on the ears by wire springs soldered to the pipe-feet, exactly as shown in Fig. CCCXLI.

VIOLIN.—We now come to the consideration of the modern string-toned stops,

whose voices imitate to a remarkable extent the compound tones of the orchestral string instruments; namely, the Violin and Violoncello. Under the names VIOLIN, CONCERT VIOLIN, and VIOLE D'ORCHESTRE, we find remarkable stops, which have been voiced by certain English artists, foremost among whom stood the late William Thynne, of London, and foremost among whom to-day stands John W. Whiteley, late of London. Both these renowned voicers have produced stops whose tones so closely imitate those of the orchestral string instruments as to be positively deceptive. We have, as a matter of curiosity, tested pipes, voiced by Mr. Thynne, alongside the orchestral Violin, and the imitation was so perfect that we could defy listeners in an adjoining room to say whether they heard the pipes or the Violin when one or the other was sounding; or when both were sounding in perfect unison, which of them it was that dropped out of the combination when one or the other was silenced. It is unnecessary to comment on the immense value of imitative voices of this class in artistic organ appointment. It is not too much to say that a Concert-room Organ without a full complement of such high-class imitative string-toned stops is hopelessly insufficient; and the same can now be safely said of a Chamber Organ schemed on our advanced principles of tonal appointment. Such imitative stops are also valuable, but to lesser degree, in large Church Organs, where, judiciously and artistically used, they may produce effective accompanimental combinations and solo effects.

In attempting to treat of the construction of the imitative string-toned stops which have been designed and fabricated by the English artists whose names have been mentioned, we are confronted with difficulties which neither pen nor pencil can adequately cope with. Such being the case, it is only possible for us to state a few general facts relative to scales and mouth treatments derived from representative stops. The range of the scales which have been adopted in the fabrication of the imitative string-toned stops of the VIOLIN and VIOLONCELLO class is greater than the range presented by any other class of organ stops, ancient or modern. This statement is fully supported by the fact that the scales used by Mr. Thynne and Mr. Whiteley for the CC (8 ft.) pipes of their stops range from a diameter of 3·13 inches to the small diameter of 1·13 inches, the former scale being developed on the ratio 1 : 2·519, while the latter appears to be on the ratio 1 : 2. The largest scale favored by Mr. Whiteley for his "small VIOLS, 8 FT.," gives the CC pipe a diameter of 1·88 inches; and it approximates the ratio 1 : 2·3. From the accompanying diagram, Fig. CCCXLII., some idea may be readily formed of the extreme scales of the CC pipes above given, in comparison with a CC pipe of the PRINCIPAL or OPEN DIAPASON, 8 FT., of normal scale. The respective diameters are as accurately rendered as practicable in so small a diagram, while the respective lengths of the pipes are only approximate. It will be observed that the VIOLS are slotted, a treatment apparently invariably followed by the artists we have named. As slotting has a decided tendency to impart a horny character to the tonality of a pipe, unless it is made wider than three-fifths the diameter of the pipe, it must be adopted with great judgment and always under the guidance of long experience. When the slots exceed three-fifths the diameters of the pipes, they may be considered simply as tuning devices, having the strips cut from them

coiled up or bent so as to open or close the slots. We, however, do not approve of tuning by such a method, as there is always a risk of affecting the *timbre* of the pipes. These remarks apply only to such pipes as yield pure organ-tone, flute-tone, and imitative string-tone, all of which tones have no affinity with a hard horny tonality. It must be admitted, however, that slotting, in the hands of an artistic voicer, may be employed to produce valuable varieties of *timbre* in certain classes of stops. As a common tuning expedient it is to be emphatically condemned.

The mouths of the string-toned pipes of which we have given the scales vary slightly in their widths. In the largest scale adopted by Mr. Thynne the mouth of the CC pipe is two-ninths its circumference. This width is graduated to one-third at c^2, that proportion being retained to the top note. In the largest scale favored by Mr. Whiteley for his series of "small VIOLS," the mouth of the CC pipe is one-fifth the circumference. This width is gradually increased in the pipes of the bass and two following octaves to one-fourth at c^2, that proportion being retained to the top note. In the smallest scale the mouth of the CC pipe is two-ninths its circumference, while from the c^2 pipe to the top the mouths are two-sevenths the circumferences of the respective pipes. The heights of the mouths in these pipes vary from one-fourth to one-third their widths; but no fixed rules or clear directions can be formulated in this matter, as the pressure of wind employed—ranging between 2⅛ inches and 15 inches in executed examples—and the character of the tone desired are controlling factors. In the matter of nicking it is also difficult to lay down directions of general application. Alluding to his own methods, Mr. Whiteley says: "Wide nicks, placed about the width of the nicks apart, induce fulness of tone. If this nicking is placed too close together, or made deeper than wide, it will incline the speech toward unsteadiness. The same tendency obtains if the mouth is too high or too wide. The lighter the wind-pressure, the fewer and finer the nicks. In some cases I have nicked the lip only, and in others the languid only. My general practice is to nick the languid sufficiently to master the dry, acrid quality of the first speech, then to nick the lip in proportion to the amount of bloom I desire for the particular stop in hand. It is quite easy to obtain a slow, dry, acrid tone; the difficulty is to get rid of it, and maintain the desirable freshness and bloom

FIG. CCCXLII.

combined with promptness of speech. I claim for my works," continues this accomplished voicer, "whether of large or small scales, that they are absolutely perfect in repetition, firmly voiced, and not easily upset. I have voiced VIOL stops on wind-pressures ranging from 2½ to 15 inches, and in many different degrees of strength, from a bold incisive keenness to the most delicate and characteristic *timbre* possible."

We now come to the indispensable adjunct to the mouths of all the imitative string-toned pipes; namely, the harmonic-bridge—an improvement on the *frein harmonique* already described. The best form of the harmonic-bridge is the cylindrical, although the semi-cylindrical shape was commonly used by the late Mr. Thynne for pipes from the tenor octave upward. The shape, however, has not very much influence; in the production of the proper tone the position of the harmonic-bridge is practically everything. The requisite position with re-

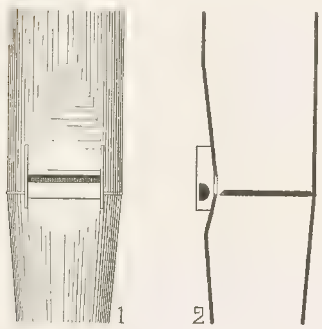


FIG. CCCXLIII.

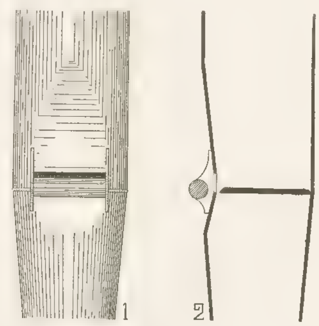


FIG. CCCXLIV.

spect to the lower lip of the mouth cannot be fixed by any rule; it has to be determined by actual test in the case of every individual pipe: and as this determination is governed by the musical sense and delicacy of ear on the part of the voicer, one can easily understand why the works of different voicers vary to the great extent they do. The vast influence the harmonic-bridge exercises over the normal tone of an open pipe can be realized when it is known that it is possible to so place it, with respect to the mouth, that it will cause the pipe to sound the sub-octave as well as its ground tone; while, on the other hand, it can be so adjusted as to invest the ground tone with a complex structure of upper partials, imitative of the compound tones of the orchestral string instruments. It is in this latter direction that the great value of the harmonic-bridge obtains in pipe construction. For pipes longer than four feet, and of medium scales, the harmonic-bridges may be of close-grained hardwood, preferably boxwood, turned and highly polished; and for smaller pipes they should be of aluminium tubing, of the several diameters required for the different sizes of pipes. Instead of such

tubing, bridges of hard pipe-metal, cast to graduated sizes, are commonly used. Mr. Thynne used pipe-metal bridges of semi-cylindrical form; but Mr. Whiteley prefers aluminium tubing, and, certainly, nothing could be better from any point of view. Bridges of this material are light, firm, smooth, and do not corrode. No definite measurements can be formulated for the diameters of the bridges, for they depend on the dimensions of the mouths, the wind-pressure employed, and, above all, on the character of tone required, and the peculiar method of the voicer in securing that tone. Accordingly, we find considerable differences both in the diameters and positions of the harmonic-bridges in the imitative string-toned pipes of different makers, just as we find in them marked differences of tone. The bridges are supported between the projecting ears of the mouths, and when accurately adjusted by the voicer, are fixed by screws or pins driven through the ears, by projections punched from the ears, or by solder, as the materials or forms of the bridges dictate. It has been found by expert voicers that the character of the string-tone and promptness of speech are to some extent influenced by the dimensions and form of the pipe-ears which support the harmonic-bridges; but here, again, no hard and fast rules obtain. Mr. Thynne and the generality of voicers have used ears of the ordinary form, as shown in Fig. CCCXLIII., while Mr. Whiteley, in his more advanced methods, uses ears cut away above and below the harmonic-bridge in the manner shown in Fig. CCCXLIV. Judging by tonal results, there seems to be no question as to the superiority of this latter form of ear for all purely imitative string-toned pipes. If the reader will glance at Fig. CCLXXXVI., given on page 475, which represents a VIOLONCELLO pipe as constructed by Mr. Whiteley, he will observe the same cut-away treatment of what are practically ears. There can be no doubt, we venture to think, that as much freedom as possible should be given to the action of the pipe-wind and its induced currents at the mouths of pipes furnished with harmonic-bridges. In the VIOLINS and VIOLONCELLOES voiced by Mr. Thynne, while their tones are very beautiful, they are somewhat slow in rapid repetition. This imperfection is entirely absent from the same stops voiced by Mr. Whiteley: and, probably, the freedom his form of ear gives to the wind at the mouth is a potent factor in securing promptness of articulation.

The Violin of the orchestra does not go below tenor G (commonly called fiddle G), and it would appear proper to stop the downward range of the imitative VIOLIN of the Organ on this note. Such a mode of procedure is certainly not to be recommended, for a short stop in any division of the Organ is an abomination and the father of endless tonal imperfections. To get over this apparent incongruity, it has been suggested to label the complete stop VIOLIN & VIOLONCELLO, 8 FT., but this is undesirable simply because there is another stop, properly called VIOLONCELLO, the tone of which closely imitates that of the orchestral instrument; and this valuable stop will in all likelihood appear along with the VIOLIN, 8 FT., in the same Organ. It should be borne in mind that if it is incorrect to carry the VIOLIN, 8 FT., below G, it is equally incorrect to carry the VIOLONCELLO, 8 FT., above g^2—the highest natural note of the true instrument in ordinary playing.

A most effective orchestral coloring has been given, in some rare cases, to the

imitative string-tone forces of the Organ by associating with the correctly-tuned unison VIOLIN one or two VIOLS of similar imitative tone, tuned slightly out of accord. When one VIOL is added, it should be of smaller scale than the solo VIOLIN, and tuned a few beats sharp; and when a second VIOL is added, it should be of a scale a pipe or two larger than the solo VIOLIN, and tuned a few beats flat. When played in combination, these stops produce the effect of a number of Violins played together in unison, just as one hears them in the orchestra.

VIOLE À SOURDINE, VIOLINO SORDO, or MUTED VIOLIN.—This stop is formed of small-scale, conical pipes, the mouths of which are treated in precisely the same manner as above described for those of the VIOLIN or VIOLE D'ORCHESTRE. The most approved scale for this stop gives the CC (8 ft.) pipe a diameter of 1·53 inches at its mouth line, and a diameter of 0·51 inch at its top, with the ratio of 1 : 2 for the complete stop. The tone of the stop imitates that of the muted Violin of the orchestra, and is a most valuable voice for the true Chamber Organ. The pipes of this stop and all the small-scale VIOLINS should be of tin, or an alloy containing not less than 75 per cent pure tin. The slender form of the pipes, especially in the bass and tenor octaves, renders a light and stiff metal imperative, to say nothing of the benefit it affords to the tone.

VIOLINO or OCTAVE VIOLIN.—This stop, of 4 ft. pitch, is properly formed of tin pipes in all respects similar in construction and voicing to the corresponding pipes of the VIOLE D'ORCHESTRE, 8 FT. It has been argued that, as the Violin sounds are sometimes carried above c^4 of the Organ, it is desirable to provide an imitative string-toned stop of octave pitch for special solo effects. There can be no doubt that such a stop would be extremely valuable in combination with the unison VIOLE D'ORCHESTRE. The pipes of the VIOLINO, 4 FT., should be made one or two pipes smaller in scale than those of the unison stop. For perfect combinational effects, the octave tones should be subordinate to the unison ones. This is a rule of universal application in the tonal structure of the Organ. An octave stop of smaller scale and more delicate intonation, under the name VIOLETTA, is to be highly recommended for the Chamber Organ, where it would produce charming effects both in solo passages and in combination with other stops of the same or different tonality. The pipes of the VIOLETTA, 4 FT., should be of small scale and, preferably, conical in form. Such a stop when softly voiced or muted would form the true OCTAVE to the VIOLINO SORDO, 8 FT.

VIOLONCELLO.—There can be no question, we venture to think, that the rich and broad tones of the orchestral Violoncello can be best imitated by wood pipes, especially in the lower octaves. While we are free to admit that admirable metal VIOLONCELLOES have been made, we strongly advise that all the pipes which are embraced in the true compass of the orchestral instrument be made of wood, while the few remaining pipes may be conveniently made of metal, voiced fuller in tone than the corresponding pipes of the VIOLIN. Full particulars respecting the imitative string-toned pipes made of wood will be found in Chapter XXXIV. When the VIOLONCELLO, 8 FT., is made entirely of metal, its pipes should be of comparatively large scale, having their mouths treated in precisely the same manner as those of the VIOLIN. The artistic voicer will proportion the mouths, execute the

nicking, and provide and fix in position harmonic-bridges of requisite diameters, so as to produce the rich full tone of the orchestral Violoncello. The stop so treated will yield a tone perfectly distinct in *timbre* from that yielded by the VIOLIN, while it will combine with it in the most satisfactory manner, producing a compound tone of great volume and rich color.

VIOLA.—Speaking of the Viola, Berlioz remarks: "Of all the instruments of the orchestra, the one whose excellent qualities have been longest misappreciated, is the Viola. It is no less agile than the Violin, the sound of its strings is peculiarly telling, its upper notes are distinguished by their mournfully passionate accent, and its quality of tone altogether, of a profound melancholy, differs from that of other instruments played with a bow." These particulars will afford some inspiration to the artistic voicer in creating the VIOLA of the Organ. They point out to him the necessity of imparting to the stop a *timbre* distinct from that of the VIOLIN and VIOLONCELLO. No words, however expressive, can educate the ear sufficiently to enable the voicer to produce a correct imitation. "There is no royal road to learning," so nothing but enthusiastic study and careful observation can lead to good results. Let the voicer call in the aid of a competent Viola player, and, in the quiet of the voicing-room, let him exercise all his knowledge and skill until his pipes yield tones that can hardly be distinguished from those of the orchestral instrument. A similar practice has been followed in producing imitations of the tones of the Violin and Violoncello, and it has been attended with marked success. In constructing and voicing the pipes of the VIOLA, 8 FT., the methods which have been found successful in connection with the pipes of the VIOLA and VIOLONCELLO will certainly have to be followed. We have not heard during our many years of observation and study in organ matters a single VIOLA stop which could be said to be strictly imitative. Generally speaking, the name may be said to be given to stops too bad to be labeled either VIOLIN or VIOLONCELLO. So much has been accomplished during late years, in certain quarters, in the construction and voicing of the imitative string-toned stops, that we expect ere long to see a perfect VIOLA, 8 FT., added to both Concert-room and Chamber Organs. It will certainly be a valuable element in the tonal coloring of the King of Instruments.

CONTRA-BASSO or VIOLONE.—Although we are of opinion that the tones of the orchestral Contra-Basso can be best imitated by wood pipes, constructed and voiced on the Schulze system, there is no question that highly satisfactory results can be obtained from metal pipes. To obtain the strictly imitative tones required, the pipes, cylindrical in form, must be of small scale; practically carrying down that of the metal VIOLONCELLO, 8 FT., and their mouths must be treated in the same manner as that above described for the unison imitative string-toned stops. When the CONTRA-BASSO, 16 FT., is inserted in a Pedal Organ (its usual place) in which a VIOLONCELLO is also inserted, it is desirable to impart a distinctive breadth of tone to it, just as one hears in the orchestra, by making its pipes of larger scale and to a slower ratio than the corresponding pipes of the VIOLONCELLO. The CONTRA-BASSO, 16 FT., descends four notes below the range of the Contra-Basso of the orchestra, while it is either four or two notes short of the upward range of the latter, according to the compass of the pedal clavier. The pipes of the CONTRA-

Basso can be made of stout zinc, having languids, upper and lower lips, ears, and toes of spotted metal. It would be well to finish their tops with short lengths of spotted or good ordinary metal, in which the slots are cut and the tuning appliances provided. There is no manner of doubt that an imitative Contra-Basso is an all-important feature of a complete Pedal Organ. It should in all Concert-room Organs be preferred to the unimitative Violone, 16 ft., so commonly met with in modern instruments.

METAL PIPES OF SPECIAL TONALITIES.

There are very few metal labial stops which yield tones which are markedly distinct from those properly classed as organ-tone, flute-tone, and string-tone; but, in saying this, we do not desire to convey the idea that the field in this direction has been thoroughly ploughed and cultivated. Some more workers are wanted in this important field, so soon as they can spare time and thought, from comparatively unimportant mechanical details, to devote to tonal matters. We may point out one direction in which very desirable results await the skilful and painstaking pipe maker and voicer; we allude to the production of certain classes of tone at present only yielded by brass instruments of the orchestra—notably the Horns. We do not despair of hearing a satisfactory imitation of the tones of the orchestral Horn produced from labial pipes: indeed, we had in our own Chamber Organ a metal stop of the Keraulophone class, from the tenor and middle octaves of which tones were produced closely resembling those of the Horn softly played. The pipes of this stop are of heavy metal (probably an alloy having 25 per cent tin), of medium scale, having mouths one-fifth the circumference of the respective pipes, and tuning-slides pierced with circular holes. On account of its peculiar tone we labeled this stop Corno di Caccia. It is also very desirable that serious essays be made to produce what is commonly understood as reed-tone from metal labial pipes. Very satisfactory results in this direction have recently been obtained from wood labial pipes, as we have recorded in Chapter XXXIV.

Keraulophone.—This valuable stop, which has been wrongly classed by Carl Locher as "belonging to the family of Geigenprincipals," is, as its name implies, the representative of a distinct class yielding horn-like tones. We have been led to understand that the invention of this stop was due to an accident which happened to a pipe in the factory of Messrs. Gray & Davison, Organ Builders, of London. At all events, the stop found its origin in that factory, and was introduced in an Organ for the first time in 1843. (See Chapter XIII.) When first made, its peculiar horn-like tone was observed, and this fact properly led to its distinctive name, derived from the Greek words κέρας—a horn, αὐλός—a pipe, and φωνή—sound.

The pipes of the Keraulophone, 8 ft., are cylindrical and of medium scale. That which, in the ratio 1 : 2·66, gives the CC pipe a diameter of 3·94 inches; the C pipe a diameter of 2·41 inches; and the c^1 pipe a diameter of 1·47 inches, may be accepted as the largest desirable scale for the stop. Smaller scales have been used by different builders, and should be used when the stop is destined for a

Chamber Organ. The mouth of the KERAULOPHONE pipe should be one-fifth the circumference of the pipe in width, and about one-fourth its own width in height. This latter proportion, however, depends on the wind-pressure used and the strength and quality of the tone desired. The upper lip is straight and not pared sharp, and the nicking of the languid is moderately fine. The mouth has small ears without any harmonic attachment. The characteristic feature of the pipe, and that which is the chief factor in imparting the refined horn-like quality to the tone, is its perforated tuning-slide of the form shown in Fig. CCCXLV. The length of the slide is about two and a half times the diameter of the pipe; and the perforation should be made at the distance of the diameter of the slide from the open end. In the CC pipe the diameter of the perforation should be 0·79 inch; in the C pipe 0·56 inch, and diminishing, in the ratio 1 : 2, to the diameter of 0·14 inch in the c^4 or top pipe of the stop. The slides must be so accurately fitted to the bodies of the pipes as to firmly retain their position while they can be easily tapped up or down in the process of tuning. In our opinion, stops of the KERAULOPHONE class have not yet received the attention they deserve; for there can be no doubt that, skilfully treated, they are capable of giving valuable voices to the Organ.

FIG. CCCXLV.

GEMSHORN.—The tone of the GEMSHORN varies considerably in different existing examples, while in all it seems to be indeterminate. In its most desirable tonality it has a bright horny *timbre*, from which it has evidently earned its name. As we have said in our brief remarks on the GEMSHORN in Chapter XIII., the usual tone of the stop may be placed between reed-tone and string-tone. This quality, valuable enough in itself, is not that which we advocate for the stop now under consideration. We have now enough of both reed- and string-tone at our disposal, and both these tonalities should be eliminated from the voice of the GEMSHORN, leaving a bright, singing, and refined horn-like tone.

The pipes of the GEMSHORN are conical in form, their open tops having diameters equal to one-third of the diameters at their mouth lines. This is the accepted rule, but, like all rules in pipe-proportions, it is open to modification under artistic treatment. The scale of the GEMSHORN, like that of all other stops, varies according to the ideas of different builders and the volume of tone desired. A good scale for a Concert-room or Church Organ stop, in the ratio 1 : 2·519, gives the CC pipe a diameter, at the mouth line, of 4·96 inches and a diameter at the top of 1·62 inches; the C pipe diameters of 3·13 inches and 1·02 inches; and the c^1 pipe diameters of 1·97 inches and 0·64 inch. For a true Chamber Organ the above scale may be made four pipes smaller, the CC pipe being 4·26 inches in diameter at its mouth line. The width of the mouth should be two-ninths of the larger circumference of the pipe, and its height should be one-fourth its width. It should be furnished with large flexible ears for fine tuning so

as to render the use of the cones unnecessary. To aid the development of the desirable horn-like tone, the pipes should have narrow and somewhat long slots cut near their tops. Like the KERAULOPHONE, the GEMSHORN presents a good field for the skill and artistic manipulation of the voicer. The GEMSHORN in its best form is an 8 ft. stop, but in German, Dutch, and other European Organs it also appears of 4 ft. and 2 ft. pitch. In these pitches its horny tone is practically sacrificed. The pipes of the unison stop should always be made of spotted or confluent metal of good thickness.

FIG. CCCXLVI.

ERZÄHLER.—This somewhat fanciful name, said to have been suggested by a peculiar tonality, has been given by Mr. Ernest M. Skinner, Organ Builder, of Boston, Mass., to a stop recently (1904) introduced by him. The ERZÄHLER pipe is very similar in general form to the GEMSHORN, as may be seen from the outline given in Fig. CCCXLVI. It differs from the GEMSHORN pipe, however, in having the diameter of its top opening only one-fourth of the diameter at its mouth line; in being slötted; and in having a mouth width equal only to one-fifth of the larger circumference of the body. The tone of the pipe is compound and singularly bright, in it the octave is distinctly heard in combination with the unison or ground tone. This is due to the peculiar form of the pipe. It is well known that if a conical pipe is stopped and over-blown, it sounds its octave, just as if it was an open cylindrical pipe. German builders have constructed a stop of such pipes, calling it SPITZGEDECKT, but it does not seem to have come into general use, why, we cannot say. We, however, welcome the advent of Mr. Skinner's new stop, the peculiar voice of which will certainly be a valuable addition to the tonal forces of the Organ. It is refreshing to find that some organ builders are giving earnest attention to that all-important branch of their art, tone-production.

THE MITERING OF METAL PIPES.

There are many occasions when the larger pipes of open metal stops, of 16 ft. pitch, have to be reduced in length by the process of mitering. This is especially necessary when such stops are located in swell-boxes of moderate dimensions, or when they are introduced in the pedal department of Chamber Organs placed in rooms under eighteen feet in height. As we have said in connection with wood pipes, mitering should never be essayed when there is any possibility of avoiding the operation; for no labial pipe is ever improved by any alteration from its original straight form. When a pipe has to be mitered, care must be taken to make the bend as far above the center of the body as possible, so as to avoid interfering with the node. The mitering

must be of a form which gives the least obstruction to the free tremor of the air within the pipe. The two forms of mitering given in Fig. CCCXLVII., are the simplest that should be used in metal pipes: that shown at A is always preferable to that shown at B. It is easily understood how the several pieces forming the miters are sawn from the original straight body. Large-scale Principal pipes should never be mitered, unless such a treatment is imperative; but such small-scale pipes as form the Viol class can be safely mitered, provided their nodes are not interfered with.

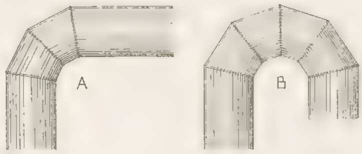


Fig. CCCXLVII.

THE TUNING OF METAL PIPES.

In the particulars given on the different forms of metal pipes in the preceding pages certain different and appropriate modes of tuning have been described; namely, in the case of open pipes, by means of adjustable slides, plain or perforated, fitted to the upper ends of the pipe-bodies; by means of the strips of metal partly cut from the slots in the upper parts of the pipes; and by means of large flexible ears adjoining the mouths of the pipes. In the case of covered and half-covered pipes, the tuning is accomplished by means of sliding metal caps; by means of stoppers inserted in the upper ends of the pipe-bodies; and by means of large flexible ears, which on being bent toward the mouth flatten the pitch and *vice versa*. Such being the case, it is only necessary in this place to consider one other mode of tuning open metal pipes; namely, that in which the implements known as "cones" and "tuning-horns" are employed. The cones are of brass, carefully turned externally and internally, of the form shown in the Side View A and Longitudinal Section B, in Fig. CCCXLVIII. They are made of several sizes, the largest of which is usually about 4 inches in diameter. The so-called tuning-horns are made of brass and sometimes of lignum-vitæ, turned after the form shown at C and D, in Fig. CCCXLVIII. They are also made of several sizes, the largest of which seldom exceeds 2 inches in diameter. The tuning of pipes is accomplished by applying either the outside or inside of these conical implements to the open ends of the pipe-bodies, either

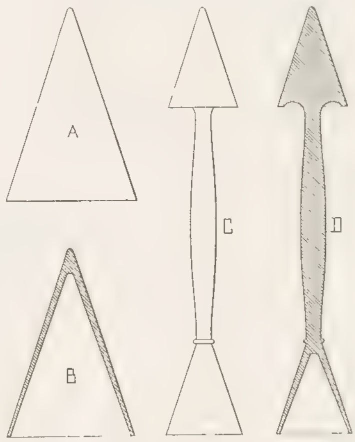


Fig. CCCXLVIII.

expanding or contracting them slightly.* A sharp, straight, downward blow, or a firm pressure accompanied with a slight rocking motion (difficult to describe) is necessary in applying the cones; and to facilitate their action on the metal of the pipes, when a considerable alteration is required, their inside surfaces should be rubbed with a little tallow, laid on with a rag on the finger-tip. But when the pipes have been accurately regulated and carefully cut to their true speaking length, only the slightest application of the cones will be necessary. In a properly-tuned pipe the effect of the cone, either in expanding or contracting its open end, should be almost imperceptible. We are aware that in many quarters tuning by the cones is considered old-fashioned; and we have observed that in these quarters pure and refined organ-tone is likewise held to be old-fashioned. The use of inferior alloy, notably that in which antimony is introduced, has done much to render tuning by cones undesirable. Such tuning is hardly to be recommended for pipes, even of the finest and toughest alloy, which are above 2 inches in diameter. For larger pipes either adjustable tuning-slides, or the simple methods illustrated in Fig. CCCXIX., should be resorted to. Under no circumstances should pipes yielding pure organ-tone be tuned by elongated slots of any proportions. On this subject we have spoken more fully in earlier pages.

* In Dom Bedos' great work we find two plates devoted to these implements. In Plate XIII. seven single cones are depicted, varying from $1\frac{1}{4}$ to $3\frac{3}{4}$ inches in diameter; and in Plate XIV. six tuning-horns, or double cones, are shown, varying from $\frac{11}{16}$ inch to $2\frac{1}{4}$ inches in diameter, and from 10 to 13 inches in length. Owing to the prevalent and objectionable method of slotting PRINCIPAL and other pipes yielding organ-tone (or which should yield it in purity), the tuning by cones is being largely abandoned, save, perhaps, in the case of small or MIXTURE pipes.

CHAPTER XXXVII.

SCALES OF LABIAL PIPES.

EACH pipe in a properly-proportioned stop has, when of metal, a different diameter, or, when of wood, a different internal width and depth, from every other pipe comprised in the several octaves of the stop; or, in other words, the internal area of each pipe differs from that of every other pipe in the stop. The rule or standard by which the correct areas are determined for all the pipes forming the stop is termed the *scale:* while the proportion which the areas of the pipes bear to each other in the successive octaves of the stop is designated the *ratio* of the scale.

The determination of desirable ratios and the subsequent development of accurate scales thereon are matters of the utmost importance in the art of pipe-making and tone-production. While at this late period in the art of organ-building the general impression obtains that the best ratios have been determined and proved by practical results, it is very questionable if everything in this direction has been accomplished. English and American organ builders have been too prone to accept the dictum of their German brethren as final and binding in scale-formation; but it is time, we venture to think, that further investigation and experiment should be entered upon, in the earnest desire to achieve a greater mastery over tone-production, brilliancy of speech, and equality of power throughout the several octaves in the different families of organ stops.

There are several old German treatises on scales, but from these absolutely no valuable lessons can be learnt. The art of organ-building, with all its present shortcomings, has advanced far beyond such elementary instructions. The first systematic treatment of the subject appears to be that of Prof. J. G. Töpfer, whose first work on the Organ was published at Weimar in 1833. He recommends for general adoption scales developed on three different ratios; namely, one in the ratio $1 : 2{\cdot}83$ ($1 : \sqrt{8}$), wherein the half measure, or half diameter, falls on the

sixteenth pipe; one in the ratio $1 : 2 \cdot 66$, wherein the half measure falls on the seventeenth pipe; and one in the ratio $1 : 2 \cdot 519$, wherein the half measure falls on the eighteenth pipe. In all the above ratios the pipe from which the calculation starts is not counted. It is necessary to remember this when referring to the tables given in this Chapter. Of the three ratios above given, Töpfer claimed $1 : \sqrt{8}$ to be the most satisfactory; and it appears to have been most generally adopted by both German and French organ builders, including Schulze and Cavaillé-Coll.* There can be no question that these ratios produce good working scales, and go as far as mathematics can well go in this direction; for it must always be remembered that organ-building is primarily an *art*, and after that a *science* in subordination. In all matters of tone-production art rules supreme, and it will dictate many departures from the dry-as-dust dicta of mathematical science, when taste and refined musical sense take the field.

Dom Bedos, in his ponderous treatise, gives numerous scales set out full size. There seems to be some system followed in the formation of these scales, but it is so erratic that we have failed to discover it. We allude to the disposition of the ordinates. Taking, for instance, the scale of the MONTRE, or open metal stop of 8 ft., we find the following irregular measurements (in inches) between the ordinates for the notes of the bottom octave: CC—$2\frac{1}{2}$ in.—CC♯—$3\frac{1}{16}$ in.—DD—$2\frac{1}{4}$ in.—DD♯—$2\frac{10}{16}$ in.—EE—$2\frac{1}{8}$ in.—FF—$1\frac{14}{16}$ in.—FF♯—$2\frac{5}{16}$ in.—GG—$1\frac{5}{8}$ in.—GG♯—2 in.—AA—$1\frac{9}{16}$ in.—AA♯—$1\frac{11}{16}$ in.—BB—$1\frac{9}{16}$ in.—C. In the scales of the BOURDONS, of 32 ft. and 16 ft., we find the ordinates disposed with a much closer approach to a regular progression. In the scale of the MONTRE, 8 FT., above alluded to, the half diameter falls between the thirteenth and fourteenth pipes,—between C♯ and D, starting from the CC note in the manner already described,—which gives a much too quick diminution, and one strongly conducive to an undesirable weakness in the treble octaves. Töpfer tried the scales given by Dom Bedos, and found them very unsatisfactory. This can be readily understood under the light of modern experience.

In the later French work by Hamel, entitled: "Nouveau Manuel Complet du Facteur d'Orgues," published in 1849, we find two ratios used: First, the ratio $2 : 3$ for the scales of "the five principal stops of the Organ,"—GAMBE, PRINCIPAL (étroit), PRINCIPAL (large), CORNET (étroit), CORNET (large),—which places the half diameter close to the fifteenth pipe. Secondly, the ratio $1 : \sqrt{8}$ for eleven general scales, which are arranged to diminish equally by two pipes, or one whole tone.

Instead of blindly following precedent, and confining himself to what has been considered satisfactory in the past, the artist in tone-production to-day may find it expedient to develop scales specially suitable for the stops he employs, for the creation of new tonal colors, and for the establishment of equality in intonation

*On this subject Mr. F. E. Robertson remarks: "Of these Töpfer says: $1 : \sqrt{8}$ is *the* scale, and his reasoning appears to be that, as the ratio of $1 : 2$ is an extreme in one direction, and $1 : 4$ in the other, the geometrical mean $\sqrt{2 \times 4}$ will be the best scale, and we need not quarrel with the logic of this deduction, as the scales have met with general approval, though experienced voicers have their fancy for particular stops."—A Practical Treatise on Organ-Building, p. 34.

throughout the several octaves. The last matter is of considerable importance and should receive careful attention. Prior to the publication of Mr. F. E. Robertson's "Practical Treatise on Organ-Building" nothing of any value on the formation of pipe-scales appeared in English works. Subsequently to the appearance of this valuable work only one author has ventured to make any special remarks on the scales for metal and wood pipes. His remarks, distributed over three pages of his book, are fragmentary and more curious than valuable. Indeed he gives a scale "scheme" which should be utterly repudiated by every one interested in artistic and scientific organ-construction.

No "rule-of-thumb method" should ever obtain in scale-formation; and if any departure is made from strictly mathematical gradation, it must be intelligently conceived and artistically carried out, and with a definite aim and purpose. Blundering rule-of-thumb methods will never answer, and should be condemned by every one who has the welfare and advancement of the art of organ-building at heart. We are afraid, on reading what the writer just alluded to says, that rule-of-thumb and unscientific methods do obtain in some quarters; and we can only suppose that it is largely due to some slipshod practice in scaling that we have so frequently heard marked tonal irregularities and imperfections in English Organs. Be this as it may, we cannot but regret that a learned author, professing to be an authority on organ matters, should speak of, and in speaking of, sanction any rule-of-thumb method, though it may be adopted by many organ workmen, and affirm that it answers practically as well as the scientific method introduced by Töpfer. We are, on the other hand, very glad that Mr. F. E. Robertson is one with us in the condemnation of such blundering methods of scale-formation: and we hope that our unqualified protest against them may lead to their abandonment by those who have used them.

Of the different methods of forming scales for labial pipes, suitable for general work, the most correct and satisfactory is that in which a straight base line is drawn and accurately divided into the required number of logarithmic abscissæ, and from each of which an ordinate is drawn perpendicular to the base line. When this has been correctly done, say, in the ordinary ratio $1 : \sqrt{8}$, it is only necessary to mark off the diameter decided on for the CC, or largest pipe of the stop, on the first ordinate, from the base line; and then to mark off in a similar manner the half of that diameter on the sixteenth ordinate (exclusive of the first on which the original diameter has been marked), and, finally, to draw a straight line obliquely from the mark on the first ordinate, onward through that on the sixteenth ordinate, and thence through all the remaining ordinates of the scale, prolonging the oblique line until it strikes the base line. In Diagram 1, in Plate VII., is shown a scale drawn in the ratio $1 : \sqrt{8}$—halving on the sixteenth step. A—B is the base line divided into sixty logarithmic abscissæ; and A—C, D—E, etc., are the ordinates determining, in conjunction with the oblique line C—B, the diameters of metal pipes. On a scale so formed, the circumferences of metal pipes may also be correctly determined. It is only necessary to lengthen the ordinates, to mark the circumference of the largest pipe on the first ordinate A—C, and then to draw an oblique line thence to the point B on the base line. All the ordinates, as cut by

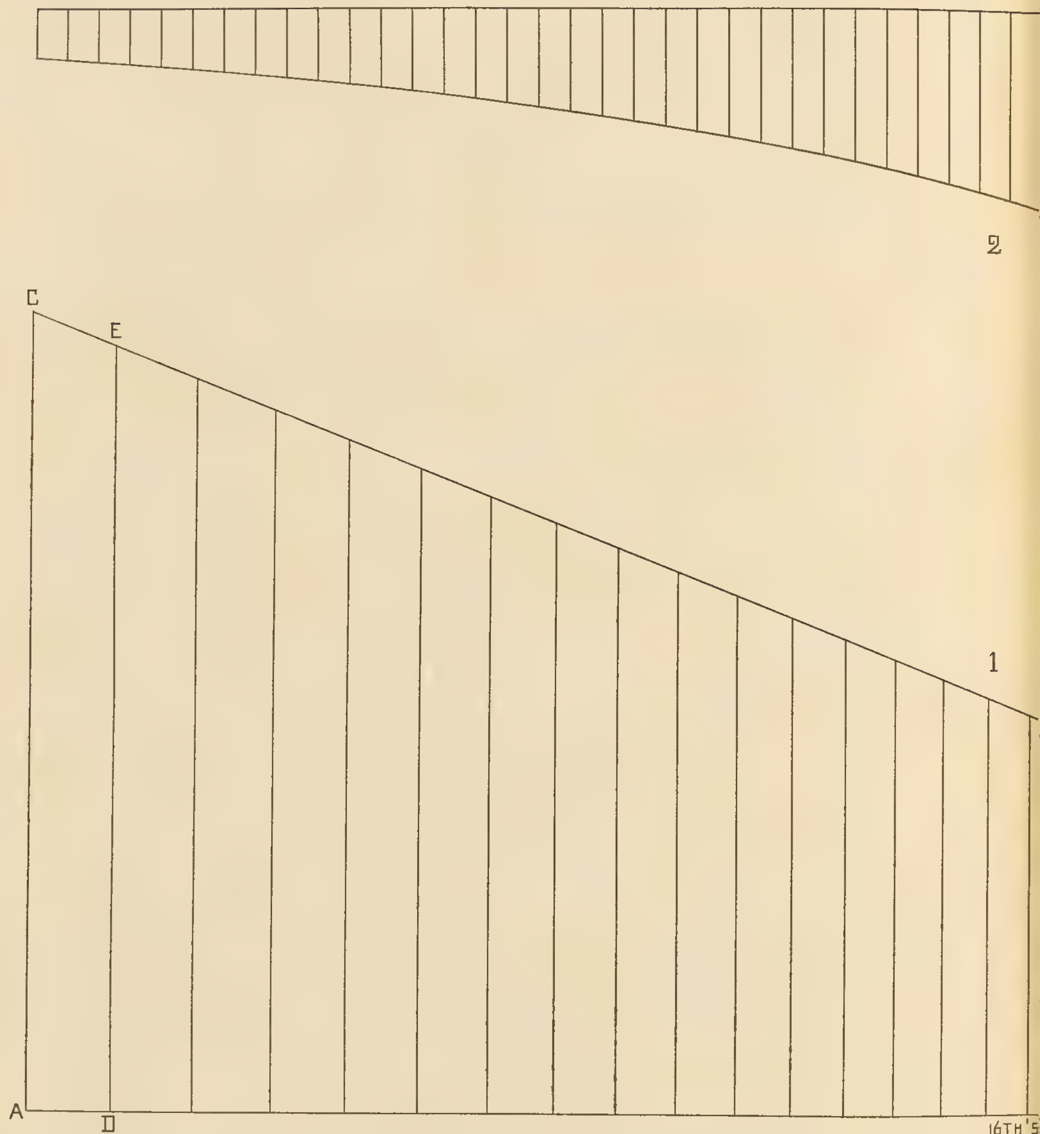
the oblique line, will give the circumferences of the different pipes correctly to the ratio of the scale. When such a scale is used for the construction of quadrangular or triangular wood pipes, all that is required is to mark off the internal width and depth of the largest pipe on the first ordinate A—C, and draw two diagonal lines from the marks to the point B on the base line. In like manner, the widths and heights of mouths, and any other dimensions requiring to be accurately graduated may be determined throughout the compass of a stop.

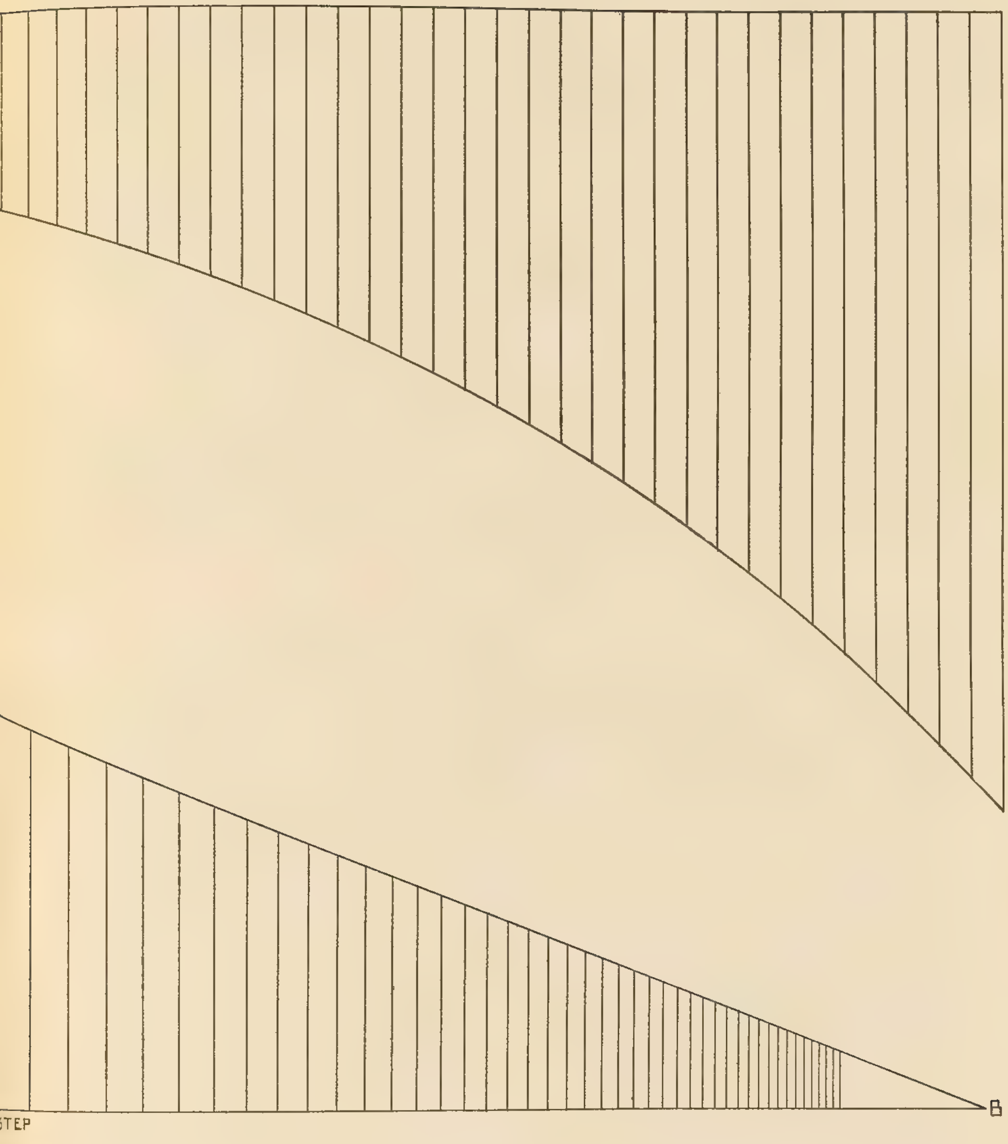
To enable the pipe maker to easily and correctly construct a scale, as above described, and to any of the approved ratios, we give the accompanying Table, in which are set forth the distances—in inches and hundredths of an inch—that separate all the ordinates occurring between the first and last ordinates of each complete series.

TABLE GIVING THE MEASUREMENTS OF THE PROGRESSIVE STEPS LOCATING THE POSITIONS OF THE ORDINATES IN PIPE SCALES ACCORDING TO DIFFERENT RATIOS.

STEPS.	HALVING ON 16TH STEP.	HALVING ON 17TH STEP.	HALVING ON 18TH STEP.	HALVING ON 20TH STEP.	HALVING ON 22ND STEP.	HALVING ON 24TH STEP.
0	2·00	2·00	2·00	2·00	2·00	2·00
1	1·91	1·92	1·92	1·93	1·93	1·94
2	1·83	1·84	1·85	1·86	1·87	1·88
3	1·75	1·77	1·78	1·80	1·81	1·83
4	1·68	1·70	1·71	1·74	1·75	1·78
5	1·61	1·63	1·65	1·68	1·70	1·73
6	1·54	1·56	1·59	1·62	1·65	1·68
7	1·47	1·50	1·53	1·56	1·60	1·63
8	1·41	1·44	1·47	1·51	1·55	1·58
9	1·35	1·38	1·41	1·46	1·50	1·54
10	1·29	1·33	1·36	1·41	1·45	1·50
11	1·24	1·28	1·31	1·36	1·40	1·46
12	1·19	1·23	1·26	1·31	1·36	1·42
13	1·14	1·18	1·21	1·26	1·32	1·38
14	1·09	1·13	1·16	1·22	1·28	1·34
15	1·04	1·08	1·11	1·18	1·24	1·30
16	1·00	1·04	1·07	1·14	1·20	1·26
17	—	1·00	1·03	1·10	1·16	1·22
18	—	—	1·00	1·06	1·12	1·18
19	—	—	—	1·03	1·09	1·15
20	—	—	—	1·00	1·06	1·12
21	—	—	—	—	1·03	1·09
22	—	—	—	—	1·00	1·06
23	—	—	—	—	—	1·03
24	—	—	—	—	—	1·00

For extreme accuracy in the measurements given in the accompanying Table it would be necessary to carry the decimals to one or two more places; but for all


2
C
E
1
A
D
16TH'S


STEP
B

practical purposes two places of decimals are amply sufficient. It requires good instruments and very great care and skill to work even to hundredths of an inch with accuracy. The measurements given in the Table can be readily laid down by the use of a scale of inches divided and lined in the manner shown in Fig. CCCXLIX. Any neat-handed workman can make such a scale by scratching its lines on a strip of zinc or hard pipe-metal. It can, of course, be extended to any desired number of inches from the decimal portion. Along the bottom line are read inches and the decimals ·10, ·20, ·30, ·40, ·50, ·60, ·70, ·80, and ·90; on the second line are read inches and, measured to the diagonal lines, the decimals ·01, ·11, ·21, ·31, ·41, ·51, ·61, ·71, ·81, and ·91; on the third line are read inches and the decimals ·02, ·12, ·22, ·32, ·42, ·52, ·62, ·72, ·82, and ·92; and so on until on the ninth line are read inches and the decimals ·09, ·19, ·29, ·39, ·49, ·59, ·69, ·79, ·89, and ·99. By applying a pair of sharp-pointed compasses to the scale great accuracy can be secured. When the first series of ordinates have been ac-

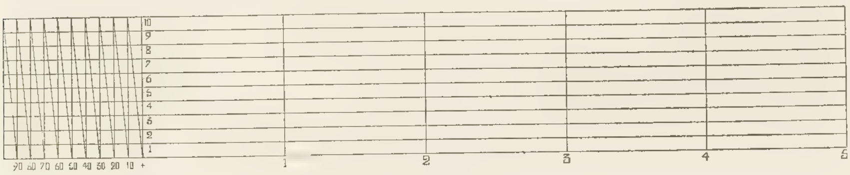


Fig. CCCXLIX.

curately set out on the base line of the pipe-scale, the second series is formed by simply halving the progressive measurements of the first series. To prevent any accumulation of errors, it is desirable to take all half measurements from the first ordinate to the others, thus: from the first to the second ordinate; from the first to the third ordinate; from the first to the fourth ordinate, and so on throughout the series. All the measurements so taken are set out on the base line from the last ordinate of the primal series, on which the half diameter is given. By this mode of proceeding, any slight error in any one of the half measurements is not extended to the others; and the second series of ordinates finishes correctly, occupying on the base line exactly half the distance covered by the primal series. The third series is derived from the second, and the fourth from the third, in precisely the same manner as above described for the setting out of the second series.*

We may now consider another and perhaps quicker method of forming a working pipe-scale. In following this method, it is only necessary to erect the requisite number of perpendicular ordinates at equidistant points on a base line, and mark on the several ordinates, which determine the ratio of the scale, the cir-

*Having furnished a practically complete set of Tables, to all the useful ratios, in the present Chapter, we have not considered it necessary to occupy space, more valuable for other matters, by giving the mathematical formulæ by which the measurements given have been obtained. To those who desire to study such formulæ, pages 33-38 of Mr. F. E. Robertson's "Practical Treatise on Organ-Building," and pages 132-149 of Töpfer-Allihn's "Die Theorie und Praxis des Orgelbaues" will doubtless be of interest.

cumferences or diameters of metal pipes, or the widths and depths of wood pipes. The first ordinate gives the dimensions of the largest pipe of the stop. When all these details have been attended to, it only remains to connect all the points marked on the special ordinates by a perfectly true curve. This can be drawn with sufficient accuracy by means of a "spline," or slender, elastic strip of celluloid, constructed for such a purpose; or a thin strip of straight-grained wood may be used. Needles should be driven into the board (on which the scale is being drawn) at the points marked on the ordinates, and the spline bent in concave fashion against all the needles, and held in that position, by the proper spline weights or by several needles, until the curve is transferred to the scale. Should any difficulty be experienced in adjusting the spline so that it comes, without local forcing, in contact with all the needles (on the ordinates) at the same time, or if the scale is a compound one, it will be necessary to apply the spline successively to the different sections, always bringing it in contact with at least three of the needles. In Diagram 2, in Plate VII., is shown a pipe-scale drawn as above described. While this method of scale-formation is not to be recommended for scales of regular gradation, it certainly is very suitable and convenient for the development of irregular or compound scales, in which quicker or slower gradations may be required in their different sections or octaves.

The following six Tables of scale measurements, in different ratios, will be found useful, either in the formation of working scales, or for checking the accuracy, or comparing the gradation, of scales developed on any special lines. It is almost unnecessary to point out the fact that, as all the calculations have been carried out to only two places of decimals, the measurements are only approximately correct. They are, however, sufficiently accurate for practical use; indeed, it would have been absurd to carry the decimals to three places, and confront the pipe maker with measurements involving thousandths of an inch. It is hardly reasonable to expect unvarying accuracy to even one-hundredth of an inch.

From the several ratios and measurements given in the Tables innumerable scales may be obtained. The dimensions placed opposite the notes of the scale are not necessarily fixed in the relations given. For instance, in Table I. the note CC (8 ft.) has a diameter of 6·32; but this diameter may be increased or diminished by starting the note on either a larger or a smaller diameter in the table; all the other note measurements taking their regular progression from it, downward and upward. As we have already mentioned, Hamel, in his "Nouveau Manuel Complet du Facteur d'Orgues," gives a Table (ratio $1 : \sqrt{8}$) containing the notes of the scale arranged in eleven columns containing the diameters and circumferences. Eleven scales are thus graphically shown in which the diameter of the CC pipe varies from 211·477 to 088·9151 millimètres. It is not desirable in practice to use a scale having a gradation quicker than that given by the ratio $1 : \sqrt{8}$, which places the half diameter on the seventeenth pipe,—that is, on the sixteenth step or progression from any pipe in the scale,—notwithstanding the fact that the French authority, Hamel, advocates the ratio 1 : 3, which places the half diameter, according to his series of Tables, practically on the sixteenth pipe, or fifteenth step, in the scales of what he calls the "five principal stops of the Organ."

I. TABLE OF SCALE MEASUREMENTS IN INCHES, RATIO $1:\sqrt{8}$— HALVING ON THE SIXTEENTH STEP.

NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD. PIPE	NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD. PIPE
1	CCCC	16·40	51·52	14·56	12·88	45	G♯	2·44	7·66	2·16	1·91
2	CCCC♯	15·72	49·36	13·92	12·32	46	A	2·33	7·32	2·06	1·83
3	DDDD	15·04	47·24	13·32	11·80	47	A♯	2·23	7·01	1·98	1·75
4	DDDD♯	14·40	45·24	12·76	11·32	48	B	2·14	6·72	1·90	1·68
5	EEEE	13·80	43·32	12·24	10·84	49	c^{1}	2·05	6·44	1·82	1·61
6	FFFF	13·20	41·48	11·72	10·36	50	$c\sharp^{1}$	1·96	6·17	1·74	1·54
7	FFFF♯	12·64	39·72	11·20	9·92	51	d^{1}	1·88	5·90	1·66	1·47
8	GGGG	12·12	38·08	10·72	9·52	52	$d\sharp^{1}$	1·80	5·65	1·59	1·41
9	GGGG♯	11·60	36·44	10·28	9·12	53	e^{1}	1·72	5·41	1·53	1·35
10	AAAA	11·12	34·92	9·84	8·72	54	f^{1}	1·65	5·18	1·46	1·29
11	AAAA♯	10·64	33·44	9·44	8·36	55	$f\sharp^{1}$	1·58	4·96	1·40	1·24
12	BBBB	10·20	32·04	9·04	8·00	56	g^{1}	1·51	4·76	1·34	1·19
13	CCC	9·76	30·64	8·64	7·64	57	$g\sharp^{1}$	1·45	4·55	1·28	1·14
14	CCC♯	9·32	29·28	8·24	7·32	58	a^{1}	1·39	4·36	1·23	1·09
15	DDD	8·92	28·04	7·92	7·00	59	$a\sharp^{1}$	1·33	4·18	1·18	1·04
16	DDD♯	8·56	26·88	7·60	6·72	60	b^{1}	1·27	4·00	1·13	1·00
17	EEE	8·20	25·76	7·28	6·44	61	c^{2}	1·22	3·83	1·08	0·95
18	FFF	7·86	24·68	6·96	6·18	62	$c\sharp^{2}$	1·16	3·66	1·03	0·91
19	FFF♯	7·52	23·62	6·66	5·90	63	d^{2}	1·11	3·50	0·99	0·87
20	GGG	7·20	22·62	6·38	5·66	64	$d\sharp^{2}$	1·07	3·36	0·95	0·84
21	GGG♯	6·90	21·66	6·12	5·42	65	e^{2}	1·02	3·22	0·91	0·80
22	AAA	6·60	20·74	5·86	5·18	66	f^{2}	0·98	3·08	0·87	0·77
23	AAA♯	6·32	19·86	5·60	4·96	67	$f\sharp^{2}$	0·94	2·95	0·83	0·74
24	BBB	6·06	19·04	5·36	4·76	68	g^{2}	0·90	2·83	0·79	0·71
25	CC	5·80	18·22	5·14	4·56	69	$g\sharp^{2}$	0·86	2·71	0·76	0·68
26	CC♯	5·56	17·46	4·92	4·36	70	a^{2}	0·82	2·59	0·73	0·65
27	DD	5·32	16·72	4·72	4·18	71	$a\sharp^{2}$	0·79	2·48	0·70	0·62
28	DD♯	5·10	16·02	4·52	4·00	72	b^{2}	0·76	2·38	0·67	0·59
29	EE	4·88	15·32	4·32	3·82	73	c^{3}	0·72	2·28	0·64	0·57
30	FF	4·66	14·64	4·12	3·66	74	$c\sharp^{3}$	0·69	2·18	0·61	0·54
31	FF♯	4·46	14·02	3·96	3·50	75	d^{3}	0·66	2·09	0·59	0·52
32	GG	4·28	13·44	3·80	3·36	76	$d\sharp^{3}$	0·64	2·00	0·56	0·50
33	GG♯	4·10	12·88	3·64	3·22	77	e^{3}	0·61	1·91	0·54	0·48
34	AA	3·93	12·34	3·48	3·08	78	f^{3}	0·58	1·83	0·51	0·46
35	AA♯	3·76	11·81	3·33	2·95	79	$f\sharp^{3}$	0·56	1·75	0·49	0·44
36	BB	3·60	11·31	3·19	2·83	80	g^{3}	0·53	1·68	0·47	0·42
37	C	3·45	10·83	3·06	2·71	81	$g\sharp^{3}$	0·51	1·61	0·45	0·40
38	C♯	3·30	10·37	2·93	2·59	82	a^{3}	0·49	1·54	0·43	0·38
39	D	3·16	9·93	2·80	2·48	83	$a\sharp^{3}$	0·47	1·48	0·42	0·37
40	D♯	3·03	9·52	2·68	2·38	84	b^{3}	0·45	1·41	0·40	0·35
41	E	2·90	9·11	2·57	2·28	85	c^{4}	0·43	1·35	0·38	0·34
42	F	2·78	8·73	2·46	2·18	86	$c\sharp^{4}$	0·41	1·29	0·37	0·32
43	F♯	2·66	8·36	2·36	2·09	87	d^{4}	0·39	1·24	0·35	0·31
44	G	2·55	8·01	2·26	2·00	88	$d\sharp^{4}$	0·38	1·19	0·33	0·29

No.	Names of Notes	Diameter	Circumference	Equal Square	Width of Quad. Pipe	No.	Names of Notes	Diameter	Circumference	Equal Square	Width of Quad. Pipe
89	e^{4}	0·36	1·14	0·32	0·28	95	$a\sharp^{4}$	0·28	0·88	0·25	0·22
90	f^{4}	0·35	1·09	0·31	0·27	96	b^{4}	0·27	0·84	0·24	0·21
91	$f\sharp^{4}$	0·33	1·04	0·29	0·26	97	c^{5}	0·26	0·80	0·23	0·20
92	g^{4}	0·32	1·00	0·28	0·25	98	$c\sharp^{5}$	0·24	0·77	0·22	0·19
93	$g\sharp^{4}$	0·30	0·96	0·27	0·24	99	d^{5}	0·23	0·74	0·21	0·18
94	a^{4}	0·29	0·91	0·26	0·23	100	$d\sharp^{5}$	0·22	0·71	0·20	0·17

II. TABLE OF SCALE MEASUREMENTS IN INCHES, RATIO 1 : 2·66—HALVING ON THE SEVENTEENTH STEP.

No.	Names of Notes	Diameter	Circumference	Equal Square	Width of Quad. Pipe	No.	Names of Notes	Diameter	Circumference	Equal Square	Width of Quad Pipe
1	CCCC	14·52	45·60	12·88	11·40	33	GG♯	3·94	12·38	3·49	3·09
2	CCCC♯	13·92	43·72	12·36	10·93	34	AA	3·78	11·88	3·35	2·97
3	DDDD	13·36	41·96	11·84	10·49	35	AA♯	3·63	11·40	3·22	2·85
4	DDDD♯	12·84	40·32	11·36	10·08	36	BB	3·48	10·93	3·09	2·73
5	EEEE	12·32	38·72	10·92	9·68	37	C	3·34	10·49	2·96	2·62
6	FFFF	11·80	37·08	10·48	9·27	38	C♯	3·21	10·08	2·84	2·52
7	FFFF♯	11·36	35·68	10·08	8·92	39	D	3·08	9·68	2·73	2·42
8	GGGG	10·92	34·32	9·68	8·58	40	D♯	2·95	9·27	2·62	2·32
9	GGGG♯	10·48	32·92	9·28	8·23	41	E	2·84	8·92	2·52	2·23
10	AAAA	10·04	31·52	8·88	7·88	42	F	2·73	8·58	2·42	2·14
11	AAAA♯	9·64	30·28	8·52	7·57	43	F♯	2·62	8·23	2·32	2·06
12	BBBB	9·24	29·04	8·16	7·26	44	G	2·51	7·88	2·22	1·97
13	CCC	8·88	27·88	7·84	6·97	45	G♯	2·41	7·57	2·13	1·89
14	CCC♯	8·52	26·76	7·56	6·69	46	A	2·31	7·26	2·04	1·81
15	DDD	8·20	25·76	7·28	6·44	47	A♯	2·22	6·97	1·96	1·74
16	DDD♯	7·88	24·76	6·98	6·18	48	B	2·13	6·69	1·89	1·67
17	EEE	7·56	23·76	6·70	5·94	49	c^{1}	2·05	6·44	1·82	1·61
18	FFF	7·26	22·80	6·44	5·70	50	$c\sharp^{1}$	1·97	6·19	1·74	1·54
19	FFF♯	6·96	21·86	6·18	5·46	51	d^{1}	1·89	5·94	1·67	1·48
20	GGG	6·68	20·98	5·92	5·24	52	$d\sharp^{1}$	1·81	5·70	1·61	1·42
21	GGG♯	6·42	20·16	5·68	5·04	53	e^{1}	1·74	5·46	1·54	1·36
22	AAA	6·16	19·36	5·46	4·84	54	f^{1}	1·67	5·24	1·48	1·31
23	AAA♯	5·90	18·54	5·24	4·64	55	$f\sharp^{1}$	1·60	5·04	1·42	1·26
24	BBB	5·68	17·84	5·04	4·46	56	g^{1}	1·54	4·84	1·36	1·21
25	CC	5·46	17·16	4·84	4·28	57	$g\sharp^{1}$	1·47	4·63	1·31	1·16
26	CC♯	5·24	16·46	4·64	4·12	58	a^{1}	1·42	4·46	1·26	1·11
27	DD	5·02	15·76	4·44	3·94	59	$a\sharp^{1}$	1·36	4·29	1·21	1·07
28	DD♯	4·82	15·14	4·26	3·78	60	b^{1}	1·31	4·11	1·16	1·03
29	EE	4·62	14·52	4·08	3·62	61	c^{2}	1·25	3·94	1·11	0·98
30	FF	4·44	13·94	3·92	3·48	62	$c\sharp^{2}$	1·20	3·78	1·06	0·94
31	FF♯	4·26	13·38	3·78	3·34	63	d^{2}	1·15	3·63	1·02	0·90
32	GG	4·10	12·88	3·64	3·22						

NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD. PIPE
64	$d\sharp^{2}$	1·11	3·48	0·98	0·87
65	e^{2}	1·06	3·34	0·94	0·83
66	f^{2}	1·02	3·22	0·91	0·80
67	$f\sharp^{2}$	0·98	3·09	0·87	0·77
68	g^{2}	0·94	2·97	0·84	0·74
69	$g\sharp^{2}$	0·91	2·85	0·80	0·71
70	a^{2}	0·87	2·73	0·77	0·68
71	$a\sharp^{2}$	0·83	2·62	0·74	0·65
72	b^{2}	0·80	2·52	0·71	0·63
73	c^{3}	0·77	2·42	0·68	0·60
74	$c\sharp^{3}$	0·74	2·32	0·65	0·58
75	d^{3}	0·71	2·23	0·63	0·56
76	$d\sharp^{3}$	0·68	2·14	0·60	0·53
77	e^{3}	0·65	2·06	0·58	0·51
78	f^{3}	0·63	1·97	0·55	0·49
79	$f\sharp^{3}$	0·60	1·89	0·53	0·47
80	g^{3}	0·58	1·81	0·51	0·45
81	$g\sharp^{3}$	0·55	1·74	0·49	0·43
82	a^{3}	0·53	1·67	0·47	0·42
83	$a\sharp^{3}$	0·51	1·61	0·45	0·40
84	b^{3}	0·49	1·55	0·44	0·38
85	c^{4}	0·47	1·48	0·42	0·37
86	$c\sharp^{4}$	0·45	1·42	0·40	0·35
87	d^{4}	0·43	1·37	0·38	0·34
88	$d\sharp^{4}$	0·42	1·31	0·37	0·33
89	e^{4}	0·40	1·26	0·35	0·31
90	f^{4}	0·38	1·21	0·34	0·30
91	$f\sharp^{4}$	0·37	1·16	0·33	0·29
92	g^{4}	0·35	1·11	0·31	0·28
93	$g\sharp^{4}$	0·34	1·07	0·30	0·27
94	a^{4}	0·33	1·03	0·29	0·26
95	$a\sharp^{4}$	0·31	0·98	0·28	0·25
96	b^{4}	0·30	0·95	0·26	0·24
97	c^{5}	0·29	0·91	0·25	0·23
98	$c\sharp^{5}$	0·28	0·87	0·24	0·22
99	d^{5}	0·27	0·84	0·23	0·21
100	$d\sharp^{5}$	0·26	0·80	0·22	0·20

III. TABLE OF SCALE MEASUREMENTS IN INCHES, RATIO 1 : 2·519—HALVING ON THE EIGHTEENTH STEP.

NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD. PIPE
1	CCCC	13·00	40·84	11·52	10·20
2	CCCC♯	12·52	39·32	11·08	9·83
3	DDDD	12·04	37·84	10·64	9·46
4	DDDD♯	11·60	36·44	10·28	9·11
5	EEEE	11·16	35·04	9·88	8·76
6	FFFF	10·72	33·68	9·52	8·42
7	FFFF♯	10·32	32·40	9·16	8·10
8	GGGG	9·92	31·16	8·80	7·80
9	GGGG♯	9·56	30·00	8·48	7·50
10	AAAA	9·20	28·88	8·16	7·22
11	AAAA♯	8·84	27·72	7·84	6·93
12	BBBB	8·52	26·76	7·56	6·69
13	CCC	8·20	25·76	7·28	6·44
14	CCC♯	7·88	24·76	6·98	6·19
15	DDD	7·58	23·82	6·72	5·95
16	DDD♯	7·30	22·94	6·48	5·74
17	EEE	7·02	22·06	6·22	5·52
18	FFF	6·76	21·24	6·00	5·31
19	FFF♯	6·50	20·42	5·76	5·10
20	GGG	6·26	19·66	5·54	4·92
21	GGG♯	6·02	18·92	5·32	4·73
22	AAA	5·80	18·22	5·14	4·56
23	AAA♯	5·58	17·52	4·94	4·38
24	BBB	5·36	16·84	4·76	4·21
25	CC	5·16	16·20	4·58	4·05
26	CC♯	4·96	15·58	4·40	3·89
27	DD	4·78	15·00	4·24	3·75
28	DD♯	4·60	14·44	4·08	3·61
29	EE	4·42	13·86	3·92	3·46
30	FF	4·26	13·38	3·78	3·34
31	FF♯	4·10	12·88	3·64	3·22
32	GG	3·94	12·38	3·49	3·09
33	GG♯	3·79	11·91	3·36	2·98
34	AA	3·65	11·47	3·24	2·87
35	AA♯	3·51	11·03	3·11	2·76
36	BB	3·38	10·62	3·00	2·65
37	C	3·25	10·21	2·88	2·55

NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD. PIPE	NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD. PIPE
38	C♯	3·13	9·83	2·77	2·46	70	a^{2}	0·91	2·87	0·81	0·72
39	D	3·01	9·46	2·66	2·36	71	a♯^{2}	0·88	2·76	0·78	0·69
40	D♯	2·90	9·11	2·57	2·28	72	b^{2}	0·84	2·65	0·75	0·66
41	E	2·79	8·76	2·47	2·19	73	c^{3}	0·81	2·55	0·72	0·64
42	F	2·68	8·42	2·38	2·10	74	c♯^{3}	0·78	2·46	0·69	0·61
43	F♯	2·58	8·10	2·29	2·02	75	d^{3}	0·75	2·36	0·66	0·59
44	G	2·48	7·79	2·20	1·95	76	d♯^{3}	0·72	2·28	0·64	0·57
45	G♯	2·39	7·50	2·12	1·87	77	e^{3}	0·70	2·19	0·62	0·55
46	A	2·30	7·22	2·04	1·81	78	f^{3}	0·67	2·10	0·59	0·52
47	A♯	2·21	6·93	1·96	1·73	79	f♯^{3}	0·64	2·02	0·57	0·50
48	B	2·13	6·69	1·89	1·67	80	g^{3}	0·62	1·95	0·55	0·49
49	c^{1}	2·05	6·44	1·82	1·61	81	g♯^{3}	0·60	1·87	0·53	0·47
50	c♯^{1}	1·97	6·19	1·74	1·54	82	a^{3}	0·57	1·80	0·51	0·45
51	d^{1}	1·89	5·95	1·68	1·49	83	a♯^{3}	0·55	1·73	0·49	0·43
52	d♯^{1}	1·82	5·73	1·62	1·43	84	b^{3}	0·53	1·67	0·47	0·42
53	e^{1}	1·75	5·51	1·55	1·38	85	c^{4}	0·51	1·61	0·45	0·40
54	f^{1}	1·69	5·31	1·50	1·32	86	c♯^{4}	0·49	1·55	0·44	0·39
55	f♯^{1}	1·62	5·10	1·44	1·27	87	d^{4}	0·47	1·46	0·42	0·37
56	g^{1}	1·56	4·91	1·38	1·23	88	d♯^{4}	0·46	1·43	0·40	0·36
57	g♯^{1}	1·50	4·73	1·33	1·18	89	e^{4}	0·44	1·38	0·39	0·34
58	a^{1}	1·45	4·55	1·28	1·14	90	f^{4}	0·42	1·32	0·37	0·33
59	a♯^{1}	1·39	4·38	1·23	1·09	91	f♯^{4}	0·40	1·28	0·36	0·32
60	b^{1}	1·34	4·21	1·19	1·05	92	g^{4}	0·39	1·23	0·35	0·31
61	c^{2}	1·29	4·05	1·14	1·01	93	g♯^{4}	0·38	1·18	0·33	0·30
62	c♯^{2}	1·24	3·89	1·10	0·97	94	a^{4}	0·36	1·14	0·32	0·28
63	d^{2}	1·19	3·75	1·06	0·94	95	a♯^{4}	0·35	1·09	0·31	0·27
64	d♯^{2}	1·15	3·61	1·02	0·90	96	b^{4}	0·33	1·05	0·30	0·26
65	e^{2}	1·10	3·46	0·98	0·86	97	c^{5}	0·32	1·01	0·29	0·25
66	f^{2}	1·06	3·34	0·94	0·83	98	c♯^{5}	0·31	0·97	0·27	0·24
67	f♯^{2}	1·02	3·22	0·91	0·80	99	d^{5}	0·30	0·94	0·26	0·23
68	g^{2}	0·99	3·09	0·87	0·77	100	d♯^{5}	0·29	0·90	0·25	0·22
69	g♯^{2}	0·95	2·98	0·84	0·74						

IV. TABLE OF SCALE MEASUREMENTS IN INCHES, RATIO 1 : 2·3—HALVING ON THE TWENTIETH STEP.

NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD. PIPE	NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD. PIPE
1	CCCC	10·76	33·80	9·52	8·45	7	FFFF♯	8·80	27·64	7·80	6·91
2	CCCC♯	10·40	32·68	9·20	8·17	8	GGGG	8·48	26·64	7·52	6·66
3	DDDD	10·08	31·64	8·92	7·91	9	GGGG♯	8·20	25·76	7·28	6·44
4	DDDD♯	9·76	30·64	8·64	7·66	10	AAAA	7·92	24·88	7·02	6·22
5	EEEE	9·44	29·64	8·36	7·41	11	AAAA♯	7·66	24·06	6·78	6·02
6	FFFF	9·12	28·64	8·08	7·16	12	BBBB	7·40	23·24	6·54	5·80

NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD. PIPE	NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD. PIPE
13	CCC	7·14	22·42	6·32	5·60	57	$g\sharp^{1}$	1·55	4·87	1·37	1·21
14	CCC♯	6·88	21·62	6·10	5·40	58	a^{1}	1·49	4·70	1·32	1·17
15	DDD	6·64	20·86	5·88	5·22	59	$a\sharp^{1}$	1·44	4·54	1·28	1·13
16	DDD♯	6·42	20·16	5·68	5·04	60	b^{1}	1·39	4·38	1·23	1·09
17	EEE	6·20	19·48	5·48	4·86	61	c^{2}	1·34	4·22	1·19	1·05
18	FFF	5·98	18·80	5·30	4·70	62	$c\sharp^{2}$	1·30	4·08	1·15	1·02
19	FFF♯	5·78	18·16	5·12	4·54	63	d^{2}	1·26	3·95	1·11	0·99
20	GGG	5·58	17·52	4·94	4·38	64	$d\sharp^{2}$	1·22	3·83	1·08	0·95
21	GGG♯	5·38	16·90	4·76	4·22	65	e^{2}	1·18	3·70	1·04	0·92
22	AAA	5·20	16·34	4·60	4·08	66	f^{2}	1·14	3·58	1·01	0·89
23	AAA♯	5·04	15·82	4·46	3·96	67	$f\sharp^{2}$	1·10	3·45	0·97	0·86
24	BBB	4·88	15·32	4·32	3·82	68	g^{2}	1·06	3·33	0·94	0·83
25	CC	4·72	14·82	4·18	3·70	69	$g\sharp^{2}$	1·02	3·22	0·91	0·80
26	CC♯	4·56	14·32	4·04	3·59	70	a^{2}	0·99	3·11	0·88	0·78
27	DD	4·40	13·82	3·90	3·46	71	$a\sharp^{2}$	0·96	3·01	0·85	0·75
28	DD♯	4·24	13·32	3·76	3·32	72	b^{2}	0·92	2·90	0·82	0·72
29	EE	4·10	12·88	3·64	3·22	73	c^{3}	0·89	2·80	0·79	0·70
30	FF	3·96	12·44	3·51	3·11	74	$c\sharp^{3}$	0·86	2·70	0·76	0·67
31	FF♯	3·83	12·03	3·39	3·01	75	d^{3}	0·83	2·61	0·73	0·65
32	GG	3·70	11·62	3·27	2·90	76	$d\sharp^{3}$	0·80	2·52	0·71	0·63
33	GG♯	3·57	11·21	3·16	2·80	77	e^{3}	0·77	2·43	0·68	0·61
34	AA	3·44	10·81	3·05	2·70	78	f^{3}	0·75	2·35	0·66	0·59
35	AA♯	3·32	10·43	2·94	2·61	79	$f\sharp^{3}$	0·72	2·27	0·64	0·57
36	BB	3·21	10·08	2·84	2·52	80	g^{3}	0·70	2·19	0·62	0·55
37	C	3·10	9·74	2·74	2·43	81	$g\sharp^{3}$	0·67	2·11	0·59	0·53
38	C♯	2·99	9·40	2·65	2·35	82	a^{3}	0·65	2·04	0·57	0·51
39	D	2·89	9·08	2·56	2·27	83	$a\sharp^{3}$	0·63	1·98	0·56	0·49
40	D♯	2·79	8·76	2·47	2·19	84	b^{3}	0·61	1·91	0·54	0·48
41	E	2·69	8·45	2·38	2·11	85	c^{4}	0·59	1·85	0·52	0·46
42	F	2·60	8·17	2·30	2·04	86	$c\sharp^{4}$	0·57	1·79	0·50	0·45
43	F♯	2·52	7·91	2·23	1·98	87	d^{4}	0·55	1·75	0·49	0·43
44	G	2·44	7·66	2·16	1·91	88	$d\sharp^{4}$	0·53	1·66	0·47	0·41
45	G♯	2·36	7·41	2·09	1·85	89	e^{4}	0·51	1·61	0·45	0·40
46	A	2·28	7·16	2·02	1·79	90	f^{4}	0·49	1·55	0·44	0·39
47	A♯	2·20	6·91	1·95	1·73	91	$f\sharp^{4}$	0·48	1·50	0·42	0·38
48	B	2·12	6·66	1·88	1·66	92	g^{4}	0·46	1·45	0·41	0·36
49	c^{1}	2·05	6·44	1·82	1·61	93	$g\sharp^{4}$	0·45	1·40	0·39	0·35
50	$c\sharp^{1}$	1·98	6·22	1·75	1·55	94	a^{4}	0·43	1·35	0·38	0·34
51	d^{1}	1·91	6·01	1·69	1·50	95	$a\sharp^{4}$	0·41	1·30	0·37	0·33
52	$d\sharp^{1}$	1·85	5·81	1·63	1·45	96	b^{4}	0·40	1·26	0·35	0·31
53	e^{1}	1·78	5·60	1·58	1·40	97	c^{5}	0·39	1·22	0·34	0·30
54	f^{1}	1·72	5·40	1·52	1·35	98	$c\sharp^{5}$	0·37	1·17	0·33	0·29
55	$f\sharp^{1}$	1·66	5·21	1·47	1·30	99	d^{5}	0·36	1·13	0·32	0·28
56	g^{1}	1·60	5·04	1·42	1·26	100	$d\sharp^{5}$	0·35	1·09	0·31	0·27

V. TABLE OF SCALE MEASUREMENTS IN INCHES, RATIO 1 : 2·13—HALVING ON THE TWENTY-SECOND STEP.

NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD. PIPE	NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD PIPE
1	CCCC	9·28	29·16	8·24	7·29	45	G♯	2·32	7·29	2·06	1·82
2	CCCC♯	9·00	28·28	7·96	7·07	46	A	2·25	7·07	1·99	1·77
3	DDDD	8·72	27·40	7·72	6·85	47	A♯	2·18	6·85	1·93	1·71
4	DDDD♯	8·44	26·52	7·48	6·63	48	B	2·11	6·63	1·87	1·66
5	EEEE	8·20	25·76	7·28	6·44	49	c^{1}	2·05	6·44	1·82	1·61
6	FFFF	7·94	24·96	7·04	6·24	50	c♯^{1}	1·98	6·24	1·76	1·56
7	FFFF♯	7·70	24·20	6·82	6·05	51	d^{1}	1·92	6·05	1·70	1·51
8	GGGG	7·46	23·44	6·60	5·86	52	d♯^{1}	1·86	5·86	1·65	1·46
9	GGGG♯	7·22	22·68	6·40	5·67	53	e^{1}	1·80	5·62	1·60	1·41
10	AAAA	7·00	21·98	6·20	5·49	54	f^{1}	1·75	5·49	1·55	1·37
11	AAAA♯	6·78	21·30	6·00	5·32	55	f♯^{1}	1·69	5·32	1·50	1·33
12	BBBB	6·58	20·66	5·80	5·16	56	g^{1}	1·64	5·16	1·45	1·29
13	CCC	6·38	20·04	5·62	5·01	57	g♯^{1}	1·59	5·01	1·40	1·25
14	CCC♯	6·18	19·40	5·46	4·85	58	a^{1}	1·54	4·85	1·36	1·21
15	DDD	5·98	18·80	5·30	4·70	59	a♯^{1}	1·49	4·70	1·32	1·17
16	DDD♯	5·80	18·22	5·14	4·55	60	b^{1}	1·45	4·55	1·28	1·14
17	EEE	5·62	17·64	4·98	4·40	61	c^{2}	1·40	4·41	1·24	1·10
18	FFF	5·44	17·08	4·82	4·27	62	c♯^{2}	1·36	4·27	1·20	1·07
19	FFF♯	5·28	16·58	4·68	4·14	63	d^{2}	1·32	4·14	1·17	1·03
20	GGG	5·12	16·08	4·54	4·02	64	d♯^{2}	1·28	4·02	1·13	1·00
21	GGG♯	4·96	15·58	4·40	3·89	65	e^{2}	1·24	3·89	1·10	0·97
22	AAA	4·80	15·08	4·26	3·77	66	f^{2}	1·20	3·77	1·06	0·94
23	AAA♯	4·64	14·58	4·12	3·64	67	f♯^{2}	1·16	3·64	1·03	0·91
24	BBB	4·50	14·14	3·98	3·53	68	g^{2}	1·12	3·53	0·99	0·88
25	CC	4·36	13·70	3·86	3·42	69	g♯^{2}	1·09	3·42	0·96	0·85
26	CC♯	4·22	13·26	3·74	3·32	70	a^{2}	1·05	3·31	0·93	0·83
27	DD	4·10	12·88	3·64	3·22	71	a♯^{2}	1·02	3·22	0·91	0·80
28	DD♯	3·97	12·48	3·52	3·12	72	b^{2}	0·99	3·12	0·88	0·78
29	EE	3·85	12·10	3·41	3·02	73	c^{3}	0·96	3·02	0·85	0·75
30	FF	3·73	11·72	3·30	2·93	74	c♯^{3}	0·93	2·93	0·82	0·73
31	FF♯	3·61	11·34	3·20	2·83	75	d^{3}	0·90	2·83	0·80	0·71
32	GG	3·50	10·99	3·10	2·75	76	d♯^{3}	0·87	2·75	0·77	0·69
33	GG♯	3·39	10·65	3·00	2·66	77	e^{3}	0·85	2·66	0·75	0·66
34	AA	3·29	10·33	2·90	2·58	78	f^{3}	0·82	2·58	0·72	0·64
35	AA♯	3·19	10·02	2·81	2·50	79	f♯^{3}	0·80	2·50	0·70	0·62
36	BB	3·09	9·71	2·73	2·43	80	g^{3}	0·77	2·43	0·68	0·61
37	C	2·99	9·40	2·65	2·35	81	g♯^{3}	0·75	2·35	0·66	0·59
38	C♯	2·90	9·11	2·57	2·28	82	a^{3}	0·72	2·28	0·64	0·57
39	D	2·81	8·82	2·49	2·20	83	a♯^{3}	0·70	2·20	0·62	0·55
40	D♯	2·72	8·54	2·41	2·13	84	b^{3}	0·68	2·13	0·60	0·53
41	E	2·64	8·29	2·34	2·07	85	c^{4}	0·66	2·07	0·58	0·52
42	F	2·56	8·04	2·27	2·01	86	c♯^{4}	0·64	2·01	0·57	0·50
43	F♯	2·48	7·79	2·20	1·95	87	d^{4}	0·62	1·95	0·55	0·49
44	G	2·40	7·54	2·13	1·88	88	d♯^{4}	0·60	1·88	0·53	0·47

NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD. PIPE
89	e^4	0·58	1·82	0·51	0·45
90	f^4	0·56	1·77	0·50	0·44
91	$f\sharp^4$	0·54	1·71	0·48	0·43
92	g^4	0·53	1·66	0·47	0·41
93	$g\sharp^4$	0·51	1·61	0·45	0·40
94	a^4	0·50	1·56	0·44	0·39
95	$a\sharp^4$	0·48	1·51	0·43	0·38
96	b^4	0·47	1·46	0·41	0·37
97	c^5	0·45	1·42	0·35	0·35
98	$c\sharp^5$	0·44	1·37	0·34	0·34
99	d^5	0·42	1·33	0·33	0·33
100	$d\sharp^5$	0·41	1·29	0·32	0·32

VI. TABLE OF SCALE MEASUREMENTS IN INCHES, RATIO 1 : 2—HALVING ON THE TWENTY-FOURTH STEP.

NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD PIPE
1	CCCC	8·20	25·76	7·28	6·44
2	CCCC♯	7·96	25·02	7·06	6·26
3	DDDD	7·74	24·32	6·86	6·08
4	DDDD♯	7·52	23·62	6·66	5·90
5	EEEE	7·30	22·94	6·48	5·74
6	FFFF	7·10	22·30	6·30	5·57
7	FFFF♯	6·90	21·66	6·12	5·42
8	GGGG	6·70	21·04	5·94	5·26
9	GGGG♯	6·50	20·42	5·76	5·10
10	AAAA	6·30	19·80	5·58	4·95
11	AAAA♯	6·12	19·22	5·42	4·80
12	BBBB	5·96	18·72	5·28	4·68
13	CCC	5·80	18·22	5·14	4·55
14	CCC♯	5·64	17·72	5·00	4·43
15	DDD	5·48	17·22	4·86	4·30
16	DDD♯	5·32	16·72	4·72	4·18
17	EEE	5·16	16·20	4·58	4·05
18	FFF	5·02	15·76	4·44	3·94
19	FFF♯	4·88	15·32	4·32	3·83
20	GGG	4·74	14·88	4·20	3·72
21	GGG♯	4·60	14·44	4·08	3·61
22	AAA	4·48	14·06	3·96	3·52
23	AAA♯	4·34	13·64	3·84	3·41
24	BBB	4·22	13·26	3·74	3·32
25	CC	4·10	12·88	3·64	3·22
26	CC♯	3·98	12·51	3·53	3·13
27	DD	3·87	12·16	3·43	3·04
28	DD♯	3·76	11·81	3·33	2·95
29	EE	3·65	11·47	3·24	2·87
30	FF	3·55	11·15	3·15	2·79
31	FF♯	3·45	10·83	3·06	2·71
32	GG	3·35	10·52	2·97	2·63
33	GG♯	3·25	10·21	2·88	2·55
34	AA	3·15	9·90	2·79	2·47
35	AA♯	3·06	9·61	2·71	2·40
36	BB	2·98	9·36	2·64	2·34
37	C	2·90	9·11	2·57	2·28
38	C♯	2·82	8·86	2·50	2·21
39	D	2·74	8·61	2·43	2·15
40	D♯	2·66	8·36	2·36	2·09
41	E	2·58	8·10	2·29	2·02
42	F	2·51	7·88	2·22	1·97
43	F♯	2·44	7·66	2·16	1·91
44	G	2·37	7·44	2·10	1·86
45	G♯	2·30	7·22	2·04	1·81
46	A	2·24	7·03	1·98	1·76
47	A♯	2·17	6·82	1·92	1·71
48	B	2·11	6·63	1·87	1·66
49	c^1	2·05	6·44	1·82	1·61
50	$c\sharp^1$	1·99	6·25	1·76	1·56
51	d^1	1·93	6·08	1·71	1·52
52	$d\sharp^1$	1·88	5·90	1·66	1·47
53	e^1	1·82	5·73	1·62	1·43
54	f^1	1·77	5·57	1·57	1·39
55	$f\sharp^1$	1·72	5·41	1·53	1·35
56	g^1	1·67	5·26	1·48	1·31
57	$g\sharp^1$	1·62	5·10	1·44	1·27
58	a^1	1·57	4·95	1·39	1·23
59	$a\sharp^1$	1·53	4·80	1·35	1·20
60	b^1	1·49	4·68	1·32	1·17
61	c^2	1·45	4·55	1·28	1·14
62	$c\sharp^2$	1·41	4·43	1·25	1·10
63	d^2	1·37	4·30	1·21	1·07

NO.	NAMES OF NOTES	DIAMETER	CIRCUMFERENCE	EQUAL SQUARE	WIDTH OF QUAD PIPE
64	d♯²	1·33	4·18	1·18	1·04
65	e²	1·29	4·05	1·14	1·01
66	f²	1·25	3·94	1·11	0·98
67	f♯²	1·22	3·83	1·08	0·95
68	g²	1·18	3·72	1·05	0·93
69	g♯²	1·15	3·61	1·02	0·90
70	a²	1·12	3·51	0·99	0·88
71	a♯²	1·08	3·41	0·96	0·85
72	b²	1·05	3·31	0·93	0·83
73	c³	1·02	3·22	0·91	0·80
74	c♯³	0·99	3·13	0·88	0·78
~~75~~	~~d³~~	~~0·97~~	~~3·04~~	~~0·86~~	~~0·76~~
76	d♯³	0·94	2·95	0·83	0·74
77	e³	0·91	2·87	0·81	0·72
78	f³	0·89	2·79	0·79	0·70
79	f♯³	0·86	2·71	0·76	0·68
80	g³	0·84	2·63	0·74	0·66
81	g♯³	0·81	2·55	0·72	0·64
82	a³	0·79	2·47	0·70	0·62
83	a♯³	0·76	2·40	0·68	0·60
84	b³	0·74	2·34	0·66	0·58
85	c⁴	0·72	2·28	0·64	0·57
86	c♯⁴	0·70	2·21	0·62	0·55
87	d⁴	0·68	2·15	0·61	0·54
88	d♯⁴	0·66	2·09	0·59	0·52
89	e⁴	0·64	2·02	0·57	0·50
90	f⁴	0·63	1·97	0·55	0·49
91	f♯⁴	0·61	1·91	0·54	0·48
92	g⁴	0·59	1·86	0·52	0·46
93	g♯⁴	0·57	1·81	0·51	0·45
94	a⁴	0·56	1·76	0·49	0·44
95	a♯⁴	0·54	1·71	0·48	0·43
96	b⁴	0·53	1·66	0·47	0·41
97	c⁵	0·51	1·61	0·45	0·40
98	c♯⁵	0·50	1·56	0·44	0·39
99	d⁵	0·48	1·52	0·43	0·38
100	d♯⁵	0·47	1·47	0·42	0·37

While we do not recommend any quicker gradation than that given in Table I., we strongly advise the adoption of the slower gradations given in Tables II. and III., for metal foundation stops, mainly because they tend to impart fulness to the treble octaves of the manual compass. For PRINCIPALS, 8 FT., and their relative OCTAVES it would not be wise to follow a slower gradation than that furnished by the ratio 1 : 2·519, halving on the eighteenth step, because an undue enlargement of the treble pipes is certain to affect their relative tone-color.

For flute-toned stops, and especially those of an assertive character, the scales of slower gradations given in Tables IV., V., and VI., will be found useful. Such scales are rarely adopted by conservative builders; but that fact is no argument against their proper use in the hands of the artist, either in their entirety or in compound scaling. Such scales are specially valuable for powerful flute-toned wood stops. For the CLARABELLA, MELODIA, HOHLFLÖTE, WALDFLÖTE, and other wood stops of a kindred character we recommend the scale given in Table IV. Such a scale gives considerable fulness to the treble octaves, and is, accordingly, very valuable.

For string-toned pipes, which to-day are constructed of such varied measurements,—measurements that were never contemplated by Töpfer, or by the organ builders of his time in any country,—it is quite impossible to advise the adoption of scales of any set ratios. When it is realized that the diameters of the CC (8 ft.) pipes of the purely imitative string-toned stops, as now made by different artists, vary from, say, 3·13 inches, through numerous steps, to only 1·13 inches, one can readily see that it would be impracticable to follow any one or two standard ratios

for their scales. It is quite evident that, while the ratio 1 : 2·66 might be properly used for the largest scale, it would be altogether absurd to attempt to use it for the smallest scale, which gives the diameter of 1·13 inches for the CC pipe. The only complete ratio for this very small scale is that given in Table VI., halving on the twenty-fourth step, or the super-octave pipe. We are strongly of opinion in the case of such small stops that compound or irregular scales would be found the most suitable.

How far we are justified in advocating the adoption of compound scales; namely, those formed of two or more different ratios, is perhaps open to question, like all other deviations from the every-day methods of organ-construction: but we are strongly of opinion that under proper treatment and skilful voicing stops of compound scales would give remarkable results. One example will be sufficient to explain our meaning respecting the formation of compound scales. Take in Table I. (ratio $1 : \sqrt{8}$) the gradation from the note CC (8 ft.), having a diameter of 5·80 inches, to the note F♯, having the diameter of 2·66 inches, inclusive. Then, turning to Table III. (ratio 1 : 2·519), find a diameter which is so close to the latter as to be practically the same. This will be found on the note F, having a diameter of 2·68 inches. Follow the gradation from this note upward to the highest note required, inclusive. We form by these means a compound scale having a quick gradation from CC to F♯ = 19 notes, and a slower gradation thence to the top note of the manual compass. It is, perhaps, unnecessary to remark that the system of compound gradation as above outlined can be reversed or extended in any desirable manner to meet the artist's views.*

* On this subject the following quotation from "Die Theorie und Praxis des Orgelbaues" may not be uninteresting to the student of the art of organ-building. We give it in the original German to avoid any possible ambiguity that might attend an English rendering:

"Die variabele Mensur. Wenn sich gezeigt hat, dass ein Massverhältnis aus bestimmten Gründen innerhalb derselben Reihe geändert wird und geändert werden kann, so ist auch nicht ausgeschlossen, die ganze Reihe in ein variables Verhältnis zu bringen, falls damit éin verständiger Zweck verbunden wird. Ein konstantes Verhältnis bewirkt, dass die Dimensionen in gleichen, sei es grössern, sei es kleineren Schritten zu- und abnehmen; es kann aber auch bezweckt werden, dass die Schritte zu Anfang und Ende die grössesten und kleinsten, oder dass sie zu Anfang am grössesten, zu Ende am kleinsten sind und das sie sich dazwischen in mittleren Werten bewegen. Das alles kann gefordert werden. Ob freilich die Forderung so dringlich ist, um ihr zu Liebe eine komplizierte Mensur aufzustellen und ob man mit anderen Mitteln nicht ebensoweit kommt, ist eine andere Frage.

"Die Mensuren des Dom Bedos sind sämtlich variabel, doch nicht deshalb, weil Dom Bedos hiermit etwas besonderes bezweckte, sondern weil er es nicht besser verstand. Es ist unzweifelhaft, dass er seine Mensur aufgegeben haben würde, wenn ihm das konstante Verhältnis der geometrischen Proportion bekannt geworden wäre und er erwogen hätte, dass Flächen nicht in denselben Verhältnissen zunehmen können, wie Längen. Es ist also auch kein Grund vorhanden auf Dom Bedos zurückzugreifen.

"Wir schliessen dies Kapitel mit der Anführung zweier variabeler Mensuren des Herrn Sauer.

"Mensur der Rohrflöte (voller weicher Flötenton):

	C_o	c^0	c^1	c^2	c^3
Aufschnitt	30 mm				3½ mm
Umfang	250 "	156	100	68	48 (46)
Flächenverhältnis	1 : 2·04	1 : 2·43	1 : 2·16	1 : 2·53	

"Wie die variabele Mensur von Dom Bedos aus der Veränderung des konstanten Verhältnisses 1 : 4, so ist diese variabele Mensur aus der Veränderung des konstanten Verhältnisses 1 : 2·72 hervorgegangen, bewegt sich also in mittleren Werten. Nach diesem Verhältnis würde, wenn der Umfang für C_o = 250 mm beibehalten

We are glad to record that there is at the present time one artist in tone-production who has found the advantage of using compound scales. We allude to Mr. Thomas Pendlebury, Organ Builder, of Leigh, Lancashire. If the reader will refer to page 478 of the present Volume, he will find examples of compound scales tabulated, which show Mr. Pendlebury's system for wood stops yielding string-tone. We strongly recommend the interesting subject of compound scale-formation to the consideration and attention of all interested in organ pipe-work and tone-production, for we are convinced that it points the way to a more satisfactory tonal development than at present obtains in the generality of labial stops introduced in modern Organs.

The true and progressive artist should throw aside all rule-of-thumb methods of scale-production and concentrate his intelligence and experience on the formation of special scales adapted to the requirements of special stops. It is in our opinion, and in view of our own observation, absolutely illogical and unreasonable to expect a scale of any one ratio to be appropriate for stops of varied tonality. We freely admit the difficulty that will beset the introduction of any radical departures from the scales that have hung on the walls of organ-building workshops, for so many years, as sacred heirlooms, handed down by past generations of pipe makers, and as fixed in their way as the laws of the Medes and Persians. The shade of Töpfer hovers around them; and the very names of the great organ builders of old seem to stay the hands of those who would essay their alteration. Let it be remembered that great strides have been made since Töpfer gave his views to the world; and let it not be forgotten that although much has been done during late years in matters of tone-production, much, very much, still remains to be done before the Organ can be pronounced a perfect musical instrument, even within the limits imposed upon it in the proper order of things.

While in the six Tables of ratios the first and second columns of dimensions give the diameters and circumferences of metal pipes, the third column furnishes the measurements of the sides of squares having, approximately, the same areas as those inclosed within the corresponding circumferences. The dimensions given in the third column are, accordingly, useful in the scaling of square wood pipes. Schulze used square wood pipes for some of his imitative string-toned wood stops, a noteworthy and very fine example of which obtains in the VIOLONBASS, 16 FT., in the Pedal department of the Organ in the Church of St. Peter, Hindley, Lancashire. From measurements of this stop taken during our survey of the Organ, we

wird, auf c^3 nur 36 mm Umfang kommen; wird jedoch der Umfang für $c^3 = 48$ mm gesetzt und die Verbindungslinie gezogen, so ergeben sich obige Grössen und Verhältnisse. Zu einem ähnlichen Resultate würde man kommen bei Einführung des konstanten Verhältnisses 1: 2·28.

"Mensur der AEOLINE (Ton fein streichend):

	C_0	c^0	c^1	c^2	c^3
Aufschnitt	10	6	3·5	2	1·5
Umfang	228	124	74	44	26
Flächenverhältnis	1 : 3·28			1 : 2 86	

"Diese variabele Mensur liegt also zwischen den Verhältnissen 1 : 3 28 und 1 : 2.86 und scheint die Mensur 1 : 3 zum Fundament zu haben."

found the CCC pipe to be practically 5·46 inches square internally, and the scale of the stop developed in the ratio 1 : 2·66, halving on the seventeenth step or the FF pipe. Schulze has clearly shown the value and excellence of wood basses to metal trebles, especially in his PRINCIPALS or OPEN DIAPASONS, and the lessons he has given to the organ-building world should not be ignored. In scaling wood basses, or any wood pipes designed to carry down an otherwise metal stop, the fourth column of measurements in the several Tables will be found useful. The measurements there given decide the widths, while the diameters given in the first column of figures decide the depths of the wood pipes. For instance, if the lowest metal pipe of a stop is C, having a diameter of 3·45 inches, the BB wood pipe would properly be 2·83 inches in width. (See Table I.) But it has been found in practice that, to obtain a satisfactory junction of the tones yielded by the cylindrical metal and the quadrangular wood pipes, it is desirable to make the wood pipe about two pipes smaller than that arrived at by the method just given. We understand that this was the proportion adopted by Schulze, who was invariably successful in his joining of wood basses to metal tenors.

In using the Tables for scaling wood stops generally, the pipes which are to have a greater depth than width, or a greater width than depth, it is only necessary to find the width decided on for the CC, or the largest pipe, in the column of diameters, in the Table selected, and follow the successive measurements throughout the compass: then, in like manner, find the measurement in the same column that comes closest to the depth required for the CC pipe, and follow the successive measurements for all the higher pipes of the stop. For instance, if we decide that the scale shall be in the ratio 1 : 2·66, and that the CC pipe shall have a width of 5·46 inches, and a depth of 6·42 inches internally; then we shall find the C pipe measuring 3·34 inches in width by 3·94 inches in depth, and the c^1 pipe measuring 2·05 inches in width by 2·41 in depth, and so on. As the measurements in all the columns in the six Tables are in correct (approximately and practically) mathematical progression, it is self-evident that any of the columns can be used for the scaling of wood pipes.

In the fourth column of measurements, in all the Tables, are given, as above mentioned, the internal widths of quadrangular wood pipes, the internal depths of which are understood to be the same as the diameters of the corresponding metal pipes given in the first column of measurements. The internal transverse areas of quadrangular pipes so dimensioned are approximately those of the corresponding cylindrical pipes. The measurements in the fourth column also give the widths of metal-pipe mouths, practically one-fourth of the circumference of the corresponding cylindrical pipes.

The Tables can also be used for the correct scaling of conical or tapered pipes, such as those forming the SPITZFLÖTE, GEMSHORN, and DOLCE. It is only necessary to find the measurements required for the CC or largest pipe, at the mouth-line and at the open top, and then follow the successive measurements for all the higher pipes of the stop. From what has been said it will be clearly seen that from the six Tables any desirable simple or compound scales (according to the standard ratios) can be derived for cylindrical and tapered metal stops, and for straight

quadrangular and triangular, and tapered wood stops. In the three Tables given by Mr. F. E. Robertson, in his valuable "Treatise," four columns are devoted to measurements giving the height of mouth, opening of wind-way, diameter of bore in foot, and the consumption of wind in each pipe of the scale. But as all these measurements are not fixed quantities, but depend on the nature and form of the pipes, manner of voicing, the strength of tone required, the pressure of the wind employed, and other controlling conditions, we have deemed it unnecessary to occupy much valuable space by adding columns of such questionable value to our extensive Tables.

In the foregoing pages no attempt has been made to formulate rules or furnish measurements for those portions of metal and wood pipes which depend entirely on the form and nature of the pipes, the quality and volume of the tone required from them, and the aim and experience of the voicer. We allude to their mouths, their wind-ways, and the wind-holes in their feet. Certain writers on organ-building have essayed to give scale measurements for these portions; but it stands to reason that such measurements are only applicable to pipes of one class, voiced on wind of one pressure, and producing one quality of tone. In short, such definite measurements are practically valueless to the artistic pipe maker and voicer. To the student of the art of organ-building, who may be disappointed at our not giving something in the nature of definite directions or tables of measurements for the sound-producing portions above spoken of, we can only say that the careful examination and accurate measurement of the pipes of different stops, made by distinguished builders, and voiced by artists in their calling, will convey more reliable and valuable information and instruction than could be derived from endless tables of dead measurements, backed by all manner of mathematical formulæ—so delightful to the inartistic, mathematical mind. In this direction, truly artistic organ-building owes nothing to mathematics; and the voicer who sells himself to formulæ will never rise beyond mediocrity, if he ever reaches that stage in his art.

The width and height of the mouth, or its area in comparison with that of the cross section of the pipe-body, are important factors in tone-production. In ordinary practice, and especially in purely trade quarters, certain standards are commonly adhered to which naturally foster the dead level of tonality which characterizes the trade Organs of to-day. The widths of the mouths of metal pipes vary, under ordinary practice, from one-fifth to two-sevenths the circumference of the pipes. The medium width, or one-quarter the circumference, appears to be that most frequently adopted; and it is certainly suitable for pipes voiced to yield pure organ-tone. As it is desirable that the widths of the mouths should follow the same ratio as that on which the pipes are scaled, it is only necessary to mark the width of the largest mouth on the first ordinate of the pipe-scale, and draw a diagonal line thence, through all the ordinates, to the vanishing point on the base line. While we say it is *desirable*, we do not assert that it is *necessary* that the same ratio should be adopted in all cases. If an increase in strength of voice is desired in the higher octaves of a stop, the width of mouth may start at one-quarter on the lowest note, and finish at two-sevenths on the highest note. Should

such a gradation be decided upon, it will only be necessary to mark the quarter of the circumference on the first ordinate of the pipe-scale, and the two-sevenths of the circumference of the highest pipe on its corresponding ordinate, and then connect the two marks by a diagonal line in the usual manner. In the case of compound scales, to which we have alluded in preceding pages, the width of mouth may, and probably should, follow the varying ratios. All these are matters subject to the taste and experience of artistic voicers; no hard and fast rules are practicable here.

In the generality of wood pipes the widths of their mouths are dictated by the interior widths of their bodies. While this may be accepted as a general rule in wood-pipe construction, and will be found exemplified in more than nine-tenths of the wood pipes introduced in ordinary modern Organs, it has no claim to universal adoption. Indeed, we are led, from our own investigations, to regret, on tonal grounds, the too slavish adherence to the rule; for we are convinced that it has largely retarded the production of many beautiful voices for the Organ. On referring to Chapter XXXIV. the student of the art of organ-building will find some noteworthy examples of successful departures from the general rule, showing, on the one hand, the width of the mouth equal to the larger interior dimension of the pipe; and, on the other hand, the width of the mouth considerably less than the smaller interior width of the pipe, not to mention the circular mouths of the imitative flute-toned pipes. The present vitiated taste for loud tones with their inherent coarseness, and the present craze for high wind-pressures will, we are afraid, seriously retard the development of pure, delicate, and refined tonalities, for the production of which properly-formed and artistically-voiced wood pipes are so admirably suited.

Much that has been said respecting the width of the mouth, applies with equal force to its height; but much greater variety of relative measurements obtains in the adjustment of height, while an entirely new factor in tone-production appears in the form of the upper lip of the mouth.

Several attempts have been made by writers on the Organ to give formulæ for determining the speaking lengths of open and covered metal and wood pipes forming complete stops; but practical experience goes to prove that such formulæ are worth little more than the paper on which they are written. This may appear a very bold statement; but when we bear in mind the several following conditions which affect the speaking lengths of pipes, the statement does not seem so unreasonable; we allude to the musical pitch adopted; the large, medium, or small scale of the pipes; the peculiar form of the pipes; the pressure of wind employed; the size of the wind-holes in the pipe-feet; the proportions and treatments of the mouths of the pipes; the methods of tuning; and the position of the pipes in the Organ with respect to adjoining pipes or any other shading surfaces or objects. Every one of the above conditions is a factor in determining the exact speaking lengths of pipes as they stand properly regulated and tuned in the Organ.

It is possible, however, putting aside the usual factory scales, which have been arrived at by facts, observation, and experience, to obtain approximate lengths of pipes of different scales by means of the empirical formulæ devised by the late

A. Cavaillé-Coll. These formulæ and Cavaillé-Coll's remarks on the same will be found in our Chapter on Acoustical Matters (Volume I., pages 373–4). It is enough to say that no other formulæ of a mathematical nature, based on the varying velocity of sound-conduction in air, or on the hypothetical lengths of equally hypothetical "sound waves," are any more reliable or practically useful than those of Cavaillé-Coll.*

* The following are the remarks on the present subject made by M. Hamel in his "Complément à l'ouvrage de Dom Bédos":

"Détermination de la longueur des tuyaux. Si les colonnes d'air qui vibrent dans des tubes cylindriques étaient libres à leurs deux extrémités, leur ton ne varierait pas, quelque changement qu'elles puissent subir dans leur diamètre, leurs longueurs restant les mêmes ; et le rapport de leurs octaves serait toujours 1 : 2. Mais les tuyaux étant fermés en partie du côté de l'embouchure par le biseau et par les parois qui unissent le corps avec le pied, il en résulte dans le ton un abaissement qui est d'autant plus grand que l'ouverture de la bouche est plus étroite et plus basse, et que le courant d'air est moins fort.

"Pour étudier les rapports des largeurs avec les longueurs, on a construit des tuyaux en bois et en étain; on leur a donné des dimensions de longueur et de grosseur très différentes, et on les a fait parler au moyen de bouches très basses. Pour simplifier les expériences, on ne s'est occupé que de tuyaux dans lesquels le rapport de la bouche avec la largeur et celui de la force du courant d'air avec la largeur et la hauteur étaient toujours les mêmes, et l'on a pu déduire ce principe: que *lorsque les diamètres ou les côtés des carrés se succèdent dans une proportion arithmétique, les longueurs correspondantes doivent former une progression géométrique.* Ainsi le calcul a démontré qu'un tuyau de 0^{m} 166 de diamètre sur 166 de long donnerait le même ton qu'un tuyau de 2 millimètres de diametre sur 330 millimètres de long, s'il était possible de faire parler de tels tuyaux.

"Dans la pratique, on ne rencontre pas des différences aussi énormes, et en admettant le rapport de 1 à 2 pour les octaves des tuyaux cylindriques ou prismatiques, on pourrait leur donner un excédent de longueur que l'on couperait lorsqu'on les met en ton, sans qu'il en résulte d'autre inconvénient qu'une perte inutile de matière et de main-d'œuvre ; mais comme il est bon de l'éviter, nous indiquerons les longueurs précises que doit avoir chaque tuyau selon son diapason, en prévenant toutefois qu'il est nécessaire de laisser toujours un peu plus de longueur qu'il ne faut, parce qu'il est impossible d'arriver du premier coup à un accord exact, et que, selon la force des courants d'air et l'ouverture des lumières, on pourrait se trouver quelquefois obligé de rallonger un tuyau qui aurait été coupé d'après un calcul où ces diverses modifications n'auraient pas été prévues."—Nouveau Manuel Complet du Facteur d'Orgues. Paris, 1903. p. 249.

CHAPTER XXXVIII.

REED PIPES: AND THEIR MODES OF CONSTRUCTION.

THERE is no subject in the entire range of the organ builder's art so difficult to treat by the pen as that relating to the construction, scaling, and general treatment of reed pipes. There are absolutely no established rules which aid the writer; and, accordingly, no writer on the Organ has produced anything of a standard character or of any widely-recognized value in this important branch of the art. Certain ingenious authorities, learned in mathematics, have essayed to formulate laws and lay down rules, only to find them upset and rendered utterly valueless in practice, proving in this, as in many other artistic and tonal matters, that an ounce of hard fact is worth a hundredweight of supposition or theory, however much either may be bolstered up by mathematical formulæ and apparently conclusive demonstration, arrived at, not in the practical atmosphere of the pipe-making and voicing rooms of an organ factory, but in the narrow breathing-space of the physical laboratory, furnished with the usual special and insufficient means of investigation. The writer who has, up to the present time, given the most voluminous dissertation on reed pipes is Max Allihn, in his extension of Töpfer's original treatise, entitled "Die Theorie und Praxis des Orgelbaues." In this work he devotes one hundred and seventeen pages to the subject, bristling with mathematical formulæ, and studded with tables of dimensions. Notwithstanding all such evidences of learning and research, he is forced to say as follows:

"The subject of reed pipes is a question so intricate and obscure that it creates a sensation as of one trying to find a path through a forest with which one is unacquainted, and in which numberless stray paths lead from the right road. If we undertake to offer our guidance to the reader in this realm, we do not presume to transform the rough ways into a smooth road; but with the consciousness of having taken pains in exploring the territory, and in the belief of having found some points from which right views and unprejudiced perspectives are possible. The organ builder has, at all times, had trouble with reed stops.

As experience accumulated, certain practical rules were evolved and certain conventional measurements adopted; but how different or conflicting are such rules and measurements among themselves. TRUMPETS are constructed with short and long and narrow and wide bodies; with narrow and wide and hard and soft tongues; with and without boots; and requiring high and low wind-pressure. Each builder argues and claims his practice to be the right one, and no one finds it wholly satisfactory. A stop made after old, tried measurements, will not suit in individual tones; the tone is not firmly stationary, the sound is covered, sickly. Body and boot are enlarged or shortened, the wind-hole is altered, sometimes with, sometimes without success. At length one has to be content if after long, vain labors, the stop has been made to answer fairly well. At another time the same stop constructed after the identical measurements succeeds as if by charm, and causes no trouble whatever.

"Also in themselves the processes of tone-formation show great irregularities. A body of a certain length is employed and then exchanged for others of greater lengths: the tone at first does not change at all, then it deepens in great skips, becomes muffled and sickly, begins to rattle, and then jumps back to its original pitch. Another time the tone drops and shortly afterwards jumps to a higher pitch. The TROMBONE, 16 FT., can in tuning be changed in pitch half an octave; the three-lined C can hardly be touched without its tone jumping often into quite a foreign one, out of all relation to the proper scale. Then, again, the free tongue behaves differently from the beating tongue, which forms the tone more readily, but so far as the body of the pipe is concerned is more sensitive than the free tongue. Now, if the organ builder, in view of such incalculable mishaps, is reduced to groping experimentation, away from all methodical research, it is easily understood how he forms such a pessimistic opinion about reed-work as is expressed in the German saying 'Schnarrwerk—Narrwerk' (Reed-work—Fool-work).

"Under such circumstances, the practician justly turns to theory for enlightenment; but in this matter theory is just as helpless as practice. In the case of labial pipes it has been observed that the physical process of their sound-production has by no means been sufficiently grasped; the same is the case with reed pipes, with which very few expert scientists have concerned themselves."*

The truth of the concluding remark is proved beyond question by referring to the works from the pens of Helmholtz, Tyndall, and other acousticians who have touched on matters connected with reed pipes. The only English writer who has attempted to instruct his readers in theoretical matters in this branch of the organ builder's art is Mr. F. E. Robertson, in his able work, entitled "A Practical Treatise on Organ Building." He gives, among other particulars, many interesting details derived from Töpfer and Max Allihn; but, notwithstanding his indulgence in mathematical formulæ, some of which he freely acknowledges to be "purely empirical," he does not succeed in doing more than Max Allihn has accomplished, which, for real practical service, is very little. English readers are, however, under a debt of gratitude to Mr. Robertson for bringing before them so much that is suggestive in the writings of Töpfer and Allihn, and from his own experience. In the last paragraph but one in his Chapter on the Scale of Reeds, Mr. Robertson says: "To sum up, it may be said that, though Töpfer and his latest editor, Max Allihn, have not succeeded in establishing any theory from which reed pipes can be

* We have given the greater part of this quotation in our Chapter on Acoustical Matters (Vol. I., p. 401) but to prevent breaking the thread of the present remarks by referring the reader to that Chapter, we have deemed it desirable to repeat it here.

designed, yet many thanks are due to them as the only people who (so far as the writer knows) have taken the trouble to publish the results of their experiments. Nor are their labors fruitless, for, if their scales (which are not approved by competent judges) are not the best possible, yet the information they have collected throws a light upon the behavior of reed pipes, and indicates the direction which further research into this most interesting subject should take. It is owing to the fact of there being no English translation that Töpfer's works are not more generally known and studied. Töpfer at least has explained why a striking reed will endure a considerable variation from the best length of body before it absolutely declines work, though the tone suffers all the time; and he has shown, to some extent, how to anticipate the best length, instead of taking an arbitrary size, such as the fifth or fourth, as used to be the custom."

As we are not prepared, unguarded by the impressive armor of hypothetical scales and purely empirical mathematical formulæ, to enter the forest, with its "numberless stray paths" which lead one away to pitfalls of false conclusions and thickets of perplexity, we shall rest content in directing the ardent student to the pages of the works above quoted from, for the special information they afford; and, for details respecting the speech of reed pipes, to our Chapter on Acoustical Matters Connected with Organ Pipes. It will be sufficient for the present Chapter, and consistent with the general purpose and scheme of our treatise, to give a more or less clear description of the forms and construction of the reed pipes which have been and are now introduced in Organs.

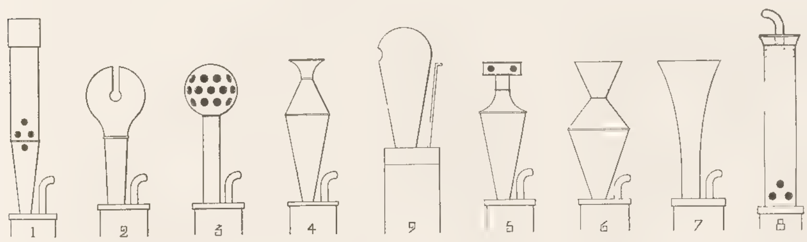


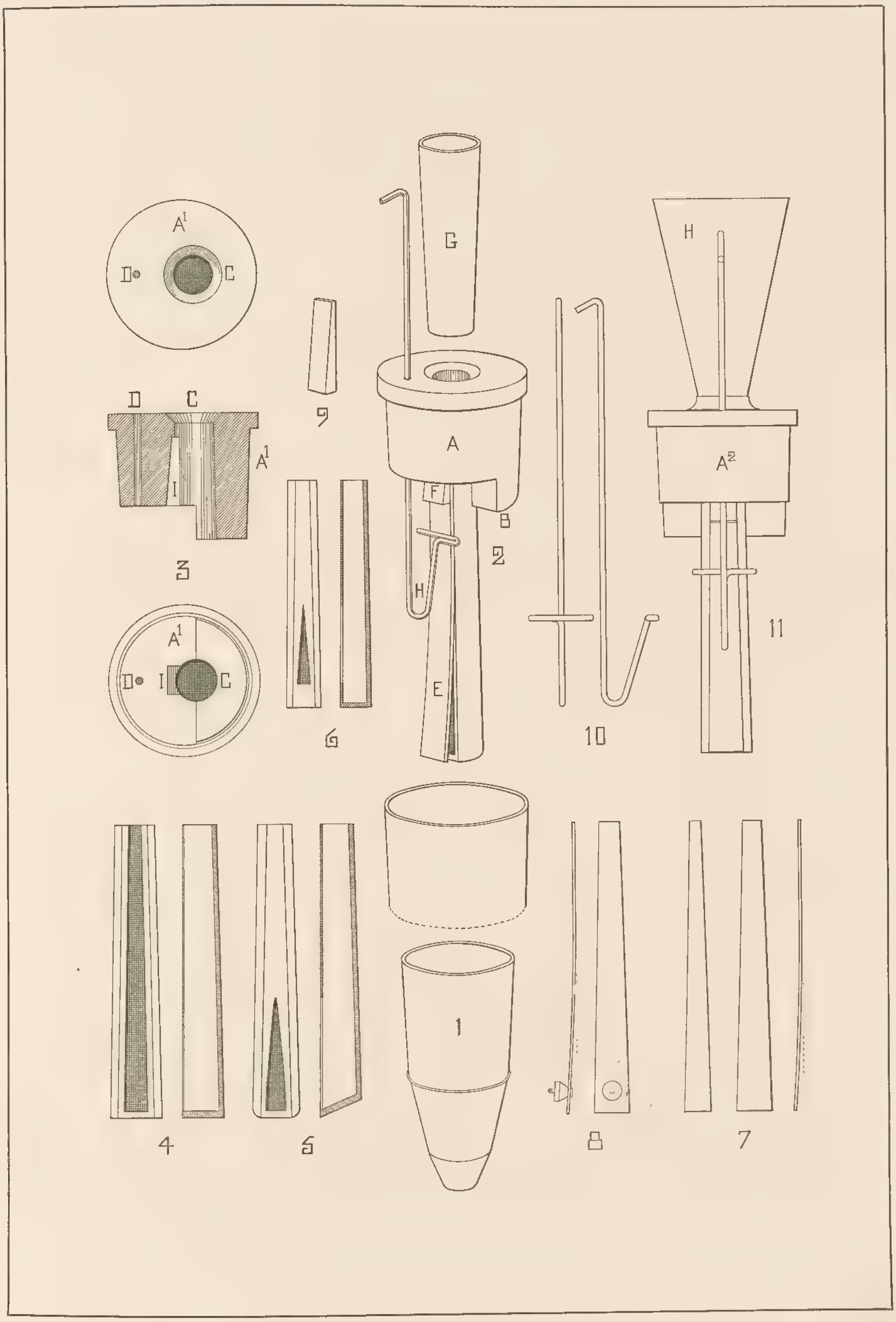
Fig. CCCL.

The early organ builders seem to have exercised their ingenuity and fancy in devising odd shapes for the resonators or bodies of their reed pipes; and it would be very interesting at the present time to hear the tones produced by such curious pipes. In the accompanying illustration, Fig. CCCL., are given outline drawings of some of the bodies or resonators of the early reed pipes just alluded to. In these representations no regard has been paid to relative scale, for they merely illustrate curiosities of organ-building. No. 1 is the Sordun, having a capped resonator pierced with several holes for the emission of sound. No. 2 is the Knopfregal, having its pear-shaped head cut after the fashion of a sleigh-bell. No. 3 is the Apfelregal, the spherical head of which is pierced with numerous small holes for

the emission of sound. No. 4 is the KRUMMHORN, the tone of which is said to have resembled that of the old instrument of the same name. No. 5 is the SCHALMEI, the tone of which imitated that of the obsolete instrument called Schalmei or Shawm. No. 6 is the BÄRPFEIFE, which yielded a subdued growling tone. No. 7 is the MESSINGREGAL, the tone of which had a brazen clang. No. 8 is the RANKET or GROSSRANKET, the resonator of which is cylindrical, stopped, and pierced close to the reed with sound-holes. No. 9 is the JEU ÉRARD, the resonator of which is pierced with a sound-hole where the inverted conical part joins the hemispherical top. The reed of this pipe being free, a very large boot was required to produce a satisfactory tone. This stop derives its name from M. Érard, who introduced it for the first time in the Organ he constructed in the year 1827 for the Chapel of the Tuileries, at Paris. This stop is said to have been invented by Grenié and made by his pupil Cosyn. With these brief remarks we may take leave of the old and obsolete reed pipes, which are interesting chiefly from a historical point of view, merely adding that in free-reed pipes still made by European builders we find resonators bearing a resemblance to some of those we have illustrated, tending to show that the old reed-pipe makers had some "method in their madness."

Before going into particulars respecting the usual forms of the several classes of reed pipes introduced in modern Organs, it is desirable that the general reader be made acquainted with the forms and construction of the several parts which constitute the sound-producing and tone-controlling portions of a normal striking-reed pipe. We have already, in our Chapter on Acoustical Matters (Vol. I., pp. 396–7), given a brief description of the sound-producing portion of such a pipe, but it is proper that we go more fully into the subject here. The several essential parts of a reed pipe are the boot; the block; the reed or *échalote;* the tongue or *languette;* the wedge; the tuning-wire; and the resonator or body. To the last-named part is sometimes added a regulator of some suitable form, as will be described farther on. The parts just mentioned may properly be described in the order adopted.

The boot is that part of a reed pipe which rests directly on the wind-chest, and into the lower end of which the pipe-wind enters on the opening of the corresponding valve or pallet in the wind-chest, and into the upper end of which is inserted the block carrying the sound-producing parts of the pipe. When formed of metal, the boot is round, slightly conical (but not necessarily so), and contracted at its lower end, which rests in the pipe-hole in the upper-board of the wind-chest. The upper and lower ends of a metal boot are shown in Diagram 1, Plate VIII. Boots as above described are properly made of good pipe-metal or stout zinc, and when of the latter material are tipped with pipe-metal. The boots are made much in the same manner as the feet of metal labial pipes, and, accordingly, call for no special details of construction here. When made of wood, the boot is quadrangular, open at its lower end, where it is screwed to, or socketed into, the upper-board of the wind-chest; and formed at its upper end to receive either a quadrangular wood block or a round metal one. Wooden boots are used only for very large reed pipes, and have been largely abandoned by pipe makers since zinc has come into favor. Boots are made of various lengths in proportion


A1
D
C
D
C
A1
I
3
A1
D
I
C
9
G
A
F
B
2
H
E
6
H
A2
11
10
4
5
1
8
7

to their diameters, according to the nature of the pipes with which they are associated. As a rule, a long boot is advantageous to the speech of a reed, and such being the case, they are sometimes used for the pipes of the Vox Humana, the resonators of which are very short, as will be pointed out later on. We have before us while we write a middle c^1 pipe of this stop, the boot of which measures 21½ inches in length, while its diameter is only 1⅛ inches. The consequent elevation of the speaking portion of the pipe is very convenient for regulating and tuning purposes. Free reeds demand very long and otherwise large boots; but, while this requirement has been demonstrated by practice, the reason for it has not been clearly arrived at.

The block is that portion of a reed pipe which is inserted in, and supported by, the upper end of the boot. It carries, pendant from it, the sound-producing apparatus of the pipe, and receives, and holds in place, on its upper surface, the lower and contracted end of the resonator or body of the pipe. In addition, the block has passing through it in a vertical direction the movable tuning-wire. The block, when of metal, is usually of the form shown in perspective at A, in Diagram 2, and in section at A^1, in Diagram 3, Plate VIII. The circular portion, slightly tapered, fits tightly into the boot, while the lower segmental portion is for the support of the reed against the pressure of the tuning-wire, as indicated at B, in Diagram 2. In small blocks, and in those of German manufacture, this segmental support is frequently omitted, the reed being simply driven firmly into the perforation in the block. Two perforations pass vertically through the block: a large and slightly-tapered one for the reception of the reed and its communication with the resonator, indicated at C, and a small one for the passage of the tuning-wire, indicated at D, in Diagram 3. The blocks are of pipe-metal, cast in metal molds of the requisite graduated sizes. In high-class work they are subsequently neatly finished in the turning lathe. We have before us as we pen these words three reed pipes of German manufacture in which the blocks are of good metal carefully turned.

The reed or *échalote* is a slightly-tapered tube of soft brass, closed at its lower and larger end with a disc of the same metal soldered on. Along the tube a perfectly flat and smooth face is formed by the file, and in this face an opening of some special form is made. According to the old method, the reed is formed by beating or swaging a plate of soft and annealed brass, of the proper size and form, around a tapered steel mandrel, a grooved iron block and wooden mallet being used in the process. The plate may require repeated annealing before it is brought to its required shape. According to the more satisfactory and expeditious modern method, the reed is made from a drawn tube of soft and annealed brass, expanded into a tapered form by means of a steel mandrel driven into it while it is supported in a tapered hole in an iron block. By this latter process a seamless tube, perfect in form, is quickly produced. The face of the reed for the reception of the tongue is now carefully made by filing or grinding, and the opening of the required form is cut in it. The reed is practically completed by having a disc of soft brass soldered to its lower end, and filed to its external form. All that remains to be done is the final filing and polishing of the face. The shape, pro-

portion, and position of the opening in the face of the reed are important factors in tone-production. The three typical treatments are illustrated in Plate VIII. In Diagram 4 is shown the "open reed," in which the opening, of a tapered form, extends from the stopped end throughout the length of the tube. This form of reed is frequently used for TRUMPETS and other loud-toned stops. In Diagram 5 is represented the so-called "closed reed," in which the opening, of a lancet form, extends from the stopped end only a moderate distance up the face of the tube. In Diagram 6 is shown a "closed reed" differing from the preceding in having its lancet-shaped opening raised a short distance above the stopped end of the tube. The proportions which these openings bear to the lengths and diameters of their tubes vary considerably in the different classes of reed pipes, and also in the same classes of pipes made by different organ builders. Absolutely no rules of universal application can be given in this matter. In the case of large pipes belonging to stops of 32 ft. and 16 ft. pitch the reeds are frequently made of some close-grained hardwood, and have their faces against which the tongues beat covered with leather. The German builders, to overcome the roughness which is liable to attend their style of voicing, commonly leather the faces of their larger brass reeds. This practice is clearly indicated in the illustrations of reed-work given in "Die Theorie und Praxis des Orgelbaues" (Plate XII.). The leather is applied chiefly on the portion of the face of the reed against which the tongue strikes, or, in other words, to a very short distance above the speaking length of the tongue when tuned. Above this the face of the reed is covered with a veneer of hard cardboard or wood, equal to the thickness of the leather, against which the tongue is held firmly by the tuning-wire. In the large reeds, such as those of the TROMBONE, 16 FT., made by the late Hilborne L. Roosevelt, both the leather and wooden veneer were commonly faced with smooth paper, providing an admirable surface for the large tongues to strike against. The brass reeds are accurately fitted to the perforations in their respective blocks, which are tapered to suit the reeds, and accurately dimensioned so as to allow the reeds to enter only the proper distance in all cases.

The tongue or *languette* is a thin and narrow strip of fine elastic brass, shaped so as to accurately cover the face of its corresponding reed. It is filed perfectly flat on both sides and so as to be uniform in thickness. Its thickness is accurately adjusted to accord with the size of the reed, and the conditions under which the voicing is conducted. An accurate gradation in thickness is as essential for the production of uniform tonality as is the gradation in the other dimensions of the tongues belonging to a stop. Several forms of gauges have been introduced or used by voicers for accurately graduating the lengths, widths, and thicknesses of tongues, and these are very conducive to satisfactory and rapid workmanship. The student of the art of organ construction will find some of these appliances depicted in Plate VI. of "Die Theorie und Praxis des Orgelbaues." Several machines have been invented and used for the purpose of scraping or planing tongues to graduated thicknesses; but whether such machines produce more satisfactory work, from an artistic and tonal point of view, than highly-skilled manipulation is open to question. Probably the combination of machine and hand work

would leave little to be desired. Two machines for planing and graduating tongues are described and illustrated in the German treatise above named (pages 388–391, and Plate XV.).

When the tongue is finished perfectly smooth and level on both its faces, and correctly fitted—in length, width, and form—to the surface of its reed, it is ready to receive its voicing- or speaking-curve. The curving of the tongue is perhaps the most exacting operation in the reed-voicer's art, demanding experience, skill, and delicacy of touch. It is usually performed as follows: The tongue is laid, with its striking-face downward, on a smooth and perfectly flat piece of very hard and close-grained wood, and its narrow or upper end is held firmly by a small block or clamp screwed down to the flat piece. Then, by means of a highly-polished cylindrical steel rod or burnisher, held firmly, by both hands, truly and squarely on the surface of the tongue toward its clamped end, and passed thence to its free end, with a motion and varying degrees of pressure which long experience and practice only can teach, and which words cannot describe, the tongue receives a slight curve upward. This burnishing process is repeated just as often as the voicer finds it necessary; that is, until the exact curvature is obtained which is requisite for the production of the special tone aimed at, combined with promptness of speech. The curvature must be perfectly true, and of such a nature that when the free end of the tongue is gently pressed down to the surface of the wood, the whole tongue will return to an absolutely flat state, just as it lay on the wood before the burnisher was applied. The slightest kink or twist in the tongue will render it useless. Machines have been devised for the curving of large and thick tongues, which have proved more or less successful in their operation. These machines apply the burnisher in a manner imitative of the operation of the hands, as above outlined, but with a degree of force and an accuracy of application that no simple manipulation can approach in the curving of large and thick tongues. The limited space at our disposal prevents our attempting to describe and illustrate these mechanical appliances. The form of the curve given to the tongue exercises not only a controlling influence over promptness of speech, but also on the character of the tone produced while it is in vibration. If one seeks information in this direction from the illustrations of reed pipes given in Dom Bedos' great work, "L'Art du Facteur d'Orgues" (Plate XVIII.), or from their reproductions in "Nouveau Manuel Complet du Facteur d'Orgues" (Plate 2), and "Die Theorie und Praxis des Orgelbaues" (Plate XI.), one will be confronted with representations of tongues having the most preposterous curves, if curves they can be called, from which no musical sound could possibly be obtained, even if they could speak at all. We cannot understand why such obviously absurd representations should be blindly copied in one book after another. We mention this to prevent the student who may examine the illustrations which have been alluded to, from being led to believe that such curves could possibly be used.* It is right to point out that in "Die

* It is much to be regretted that one meets with so many glaring inaccuracies and evidences of careless draughtsmanship in the illustrations in treatises on organ-building. Authors of books of a technical nature should bear in mind that a misrepresentation or an insufficient representation is not only valueless in itself, but destroys to a large extent the value of what may accompany it in words. Teaching through the eye is direct and certain.

Theorie und Praxis des Orgelbaues" positive inaccuracy in this direction is confined to the reproductions of the illustrations given in Dom Bedos' work. Other plates in the German treatise show reed-work properly formed.

There are considerable differences of tone to be observed in reed pipes of the same class constructed by German, French, and English organ builders; and many of these differences are due to the special curvatures of the tongues employed. The objectionable clang and brassiness which commonly characterize the tones of French reed pipes, and which seem to be satisfactory to the ears of the musicians of France, are mainly due to the somewhat flat manner in which the tongues strike and close the reeds: while, on the other hand, the smooth and round tones, which are the result of the best English school of reed-voicing,—founded by the late Mr. George Willis, and carried to a high pitch of perfection by his brother, the late Mr. Henry Willis, and his talented sons,—are due to the beautiful curvature imparted to the tongues, which latter, on approaching the exposed faces of the reeds, gradually relax or unroll themselves, so to speak, until they lie flat and cover the orifices in the same, avoiding anything in the nature of an absolute blow. To counteract the objectionable effects of the flat blows of the tongues, the German pipe voicers have adopted a thin leather facing to the larger reeds. This practice has much to recommend it, for however skilfully large tongues may be curved, there is always a danger of their creating a disagreeable noise while vibrating. We have alluded to this practice in our remarks on the reed.

The lengths and thicknesses of the tongues are properly dictated by the pitch of the tones they have to yield under certain controlling factors, and require to be accurately graduated throughout the series belonging to a complete stop, in accordance with some approved ratio and thickness-gauge. The widths and forms of the tongues are largely dictated by the general formation and proportions of the pipes, the character and loudness of the tones desired, and the pressure of the wind employed to set them into vibration. With such conditions affecting the formation of tongues suitable for the various classes and pitches of reed pipes, it is quite obvious that no scales of measurements of anything approaching general application can be formulated, and all attempts to produce such scales have ended in failures. Such being the case, special scales or tables of measurements are made or adopted by each reed-pipe maker or voicer for the different classes of stops—measurements which have been arrived at by experiment and experience—yielding the qualities of tone which each voicer affects. We may properly say at this point that whatever measurements are adopted, they should be based on some logarithmic scale, constructed in the manner described in the preceding Chapter. In this matter, the interested reader may profitably examine the scales (giving the lengths and widths of tongues) delineated in Plate XXXII. of "A Practical Treatise on Organ-building." †

It is safe to say that to the student a complete and accurate drawing, accompanied by a few explanatory words, is of more value than a false representation attended by pages of descriptive matter. Words may be insufficient or may be misunderstood, but a perfect drawing, fully detailed, can never fail to convey correct and sufficient information.

†Alluding to these scales, Mr. F. E. Robertson says: "A scale after Weber's ideas, as given in Hamel, is plotted in Fig. 299, Pl. XXXII., as a logarithmic scale in the ratio 1 : $\sqrt{8}$, which can be used for any series

In Diagram 7, Plate VIII., are shown the common forms of tongues as used in reed pipes of different classes. At E, in Diagram 2, the tongue is shown adjusted to the reed, and secured to the pipe-block in its proper position.

Up to this point we have been treating of tongues formed of plates of brass, practically of uniform thickness throughout their lengths. We have now to describe what are known as "loaded tongues." To avoid using tongues of inconvenient length for the production of grave tones, organ builders have adopted tongues, the free ends of which are loaded or weighted in some manner. In loading a tongue, which has been formed and curved in the manner previously described, care must be taken to leave it perfectly free to vibrate and properly strike the face of the reed. A usual and satisfactory method of accomplishing this is to attach to its outer face, near its free end, a conical brass button, the small truncated end of which rests on the tongue without in any manner interfering with its curvature or free vibration. Front and Side Views of a tongue loaded in this fashion are given in Diagram 8, Plate VIII. The conical buttons are graduated in size to accord with the different dimensions of tongues; and they are firmly secured by small screw-pins, which pass through holes drilled in the tongues in the manner indicated. The tongues of the pipes of the CONTRA-OBOE, 16 FT., from CC to f♯¹, in the Swell division of the Organ in Glasgow Cathedral are weighted in this manner. This instrument was constructed by Willis. Other methods of loading striking tongues have been adopted; namely, that of gluing some substance, such as soft leather, to the outer surface of their vibrating portions, but it is questionable if these methods, or loading in any form can be recommended. In the case of the tongues of free-reed pipes, loading is perfectly satisfactory. In the large free tongues of the BOMBARDON, 32 FT., the loading is in the form of a lead or pipe-metal plate—the width of the tongue and about one-fifth or one-sixth its vibrating length—soldered to the outside face of the tongue at its free end. This loading is discontinued where the tongue assumes moderate dimensions. Free tongues which are not loaded are usually thicker at their vibrating ends than where they are screwed to their frames. This treatment partakes of the nature of loading.

In the hopes of producing refined qualities of tone, voicers have tried tongues formed of different metals and alloys, such as hard rolled or hammered copper, soft brass, bronze, German silver, and even hard silver; but no satisfactory results have been obtained sufficient to guarantee the abandonment of hard rolled or hammered brass, the reliability of which has been long established.

The wedge is a small piece of hardwood of the form shown in Diagram 9, Plate VIII. It is used to secure the tongue, at its upper end, in the block and against the face of the reed. It is shown in position at F, in Diagram 2, while the place for its reception is indicated at I, in Diagram 3. When the tongue is

in that ratio. There are seven scales, making a difference of an octave in size, of which, for the sake of clearness, only the middle—a medium one—has been drawn throughout. These scales give the length and width of the tongues, and the diameter of the pipe and the thickness of the tongues × 1,000 is found in Fig. 298, which also can be used for any scale in the ratio 1 : 2. These diagrams have been given more for the sake of the ratios for general use, than because the particular scales drawn thereon are recommended."

held in its correct position against the face of the reed, the wedge is pressed into its place by the blade of a strong knife or any convenient tool. When the tongue has to be removed for alteration or cleaning, the wedge can be easily withdrawn by notching a knife into it and turning the blade so as to bear on the under surface of the block. In the process of voicing the tongue may have to be frequently removed, and a temporary wedge is often used until the tongue is perfected, when the permanent wedge is inserted.

The tuning-wire is represented in front and side views in Diagram 10, and in perspective at H, in Diagram 2. The wire is of unannealed steel, hard brass, or phosphor-bronze, but the last-named alloy is much to be preferred. The wire used must be of sufficient size to exert a pressure that will firmly hold the tongue against its reed and retain its position after tuning. Different sizes are employed for the large, medium, and small reeds, Nos. 13, 14, and 15 B. W. G. being suitable for the stops of 8 ft. pitch. Larger sizes are used for reeds of lower pitch. The description of wire employed to some extent dictates its gauge. The wire must be formed so as to bear upon the tongue perfectly true, and must be bent so that it will move smoothly in the process of tuning, and have no disposition to spring into another position after the tuning is finished. Weak and badly-formed tuning-wires are very apt to alter their positions and, accordingly, to throw the pipes out of tune.

The resonator, body, or tube of a reed pipe is that portion which rises from the upper surface of the block, directly over the perforation in which the reed is inserted. The office of the resonator is, to control the sound produced by the reed and tongue, and translate it into a musical tone of definite pitch and *timbre.* In the form and dimensions of the resonator—matters in connection with which no rules of general application seem to have been formulated—the peculiar acoustical properties of the reed and tongue have to be recognized; and it is evident that upon the scientific relationship of these parts the perfection of the resultant tone of a reed pipe depends. Such being the case, it is hardly to be wondered at that a perfectly satisfactory reed stop is a rare and a highly-prized possession in any Organ. A striking reed will not yield any note of truly musical character until its resonator is added; and the same reed will generate different qualities of musical tone when associated with resonators of different forms and proportions.* But the tones so produced will not be equally good; indeed, it is highly probable that only one form and size of resonator will be found to be perfectly adapted to the peculiar acoustical properties of the reed and tongue, producing a beautiful musical tone. The special and practically-fixed construction of the

* "It is not the tongue itself which gives the note: a harmonium tongue set in motion by mechanical means, or a tuning-fork, gives only a poor note; the resonating body is the column of air, to which the tongue only serves as a regulator to establish a series of rhythmical vibrations. Naturally, therefore, a reed with a body gives a finer note than one without, because the vibrating air mass is larger and more compact. The curve of the tongue also modifies the note in the case of beating reeds. A straight tongue, that in shutting closed at once the reed, would give a hard and unpleasant note; and tongues are always made with a gradual curve, for which, however, no measurements can be given, the execution depending on the skill of the voicer.

"As for beating reeds, it is probable that the influence of the body in establishing the pitch of the pipe is paramount."—Mr. F. E. Robertson, in "A Practical Treatise on Organ-building."

sound-producing portion of a reed pipe to a large extent dictates the form of its resonator; for instance, whatever the shape of the upper or main portion of the resonator may be, its lower portion, which is joined to the block, has to be (under all usual conditions) tapered to the size dictated by the diameter of the reed below, or the perforation in the block over which it is attached.

As the different forms of resonators are described and illustrated in the following particulars of the various reed stops introduced in the modern Organ, it is unnecessary to treat of them in any special manner in this place, but their modes of construction may be briefly touched upon here. Resonators are made of both metal and wood: the former being used for those of all forms and dimensions, while the latter is usually confined to resonators of large size and of inverted pyramidal form, such as are commonly used for the pipes of the CONTRAPOSAUNE, 32 FT., and the CONTRA-TROMBONE and CONTRAFAGOTTO, 16 FT. In some rare cases wood resonators have been used for small pipes, with satisfactory results tonally.

The materials used in the construction of metal resonators are tin, pipe-metal, and zinc. While the high-class alloys of tin and lead are always to be preferred, a good deal may be said in favor of the employment of zinc, especially for resonators which are long and extremely slender, such as those properly used for the ORCHESTRAL OBOE, 8 FT., CONTRA-OBOE, 16 FT., and FAGOTTO, 8 FT. The resonators are formed in precisely the same manner as are the bodies of labial pipes. The sheets of metal are cut to the proper forms and dimensions, according to templates prepared for the stop in hand, and are then rolled up on mandrels of the required shape, and subsequently soldered. While the resonators of certain stops are simply conical in form, and require only single pieces of metal in their formation, those of other stops are compound in form, and require two or more pieces in their construction. In the latter case the component parts are cut out, rolled up, and soldered separately, and finally soldered together. When zinc is employed for plain conical resonators, it must have all parts requiring manipulation in the processes of voicing, regulating, and tuning added in pipe-metal. The resonators of small pipes, or, say, those under two feet in length, are usually soldered directly to their respective blocks; but the larger resonators are properly inserted in sockets of suitable forms and dimensions, which are soldered to their corresponding blocks. This latter method is convenient and to be commended for all practical purposes. A socket suitable for an ordinary conical resonator, such as that of a TRUMPET pipe, is shown at G in Plate VIII., detached from its block A. In the Front View of a block, reed, tongue, and tuning-wire, given in Diagram 11, a socket for the reception of a resonator of a CLARINET pipe is indicated at H. Having briefly detailed the several component parts of a normal striking-reed pipe, we may now proceed to describe the different classes of reed pipes used in the modern Organ. But before proceeding farther in this Chapter, the student of the art of organ-building should read the remarks on reed pipes on pages 396–404 in Volume I.

TRUMPET.—The TRUMPET, 8 FT., may be accepted as the representative of a family of striking-reed stops, the pipes of which extend through seven octaves. The stop of 8 ft. pitch is invariably made of metal, which should be of good qual-

ity and of substantial thickness. The resonator of the TRUMPET pipe is of an inverted conical form, as shown in the accompanying illustration, Fig. CCCLI., of a length nearly that of an open labial pipe of the same pitch, and entirely open at top. In certain high-pressure TRUMPET stops the pipes have resonators of about double the normal speaking lengths. A stop of this class is commonly distinguished by the name HARMONIC TRUMPET, and its voice should be full and brilliant, imitative of that of the orchestral Trumpet played *fortissimo*. The reeds are made both open and closed, according to the character of the tone desired. For the true Chamber Organ, the TRUMPET, 8 FT., should invariably be made with closed reeds, so as to secure a somewhat mellow quality combined with the clang which should distinguish the stop. When closed reeds are used for full-toned pipes, their openings should extend fully half up their respective exposed faces. The scale which determines the diameters of the open ends of the resonators, varies considerably in different TRUMPETS, a wide scale being used for stops of powerful intonation, and a comparatively narrow scale for Chamber Organ stops.

FIG. CCCLI.

TUBA.—This stop is simply a large-scale TRUMPET, of 8 ft. pitch, and very powerful voice. It is commonly voiced on wind of from 10 to 30 inches, and finds its place in the Solo division of large Organs. When of very large scale, the stop has been designated TUBA MIRABILIS. Its reeds are properly of the open class, and its tongues are both wide and thick. Its resonators are necessarily of large scale, and of thick and firm metal, preferably spotted metal, which is capable of withstanding the extreme vibration generated by the high-pressure wind employed. The most powerful reed stop introduced in the Organ is that called HARMONIC TUBA, 8 FT., the resonators of which are about double the length of those belonging to the ordinary TUBA, 8 FT. The reeds are large and open, and the tongues broad and very thick. The pipes are overblown with wind of not less than 20 inches. The resonators are of large scale, inverted conical in form, and of great thickness. Double tongues have in some rare instances been used, but there is no need to resort to this extreme practice. Single tongues can be made to produce tones quite as loud as any musical effect can call for. The love for loud, coarse, and blatant sounds in the Organ is a purely modern craze, and can hardly be supported on artistic grounds, we venture to think.

CORNOPEAN.—From the name used to designate this stop, it might be supposed to imitate in tone the brass instrument popularly known by the same name, but in this direction it falls far short of being successful. In too many examples it is simply a bad TRUMPET. The CORNOPEAN, 8 FT., is, however, when made and voiced by a master, both a distinct and agree-

able stop. Its resonators are similar in form to those of the TRUMPET; but, in good examples, they are larger in scale, and they are never made harmonic or of double length. The reeds of the CORNOPEAN should invariably be of the closed species; and the tongues should be carefully curved to produce a tone free from the brilliant and somewhat brassy clang of the TRUMPET, while they have a firm and bold character. But, after all that can be done with this stop by the most skilful voicer, we must acknowledge that it holds about the same unsatisfactory position in the tonal forces of the Organ as the true Cornet à piston does among the instruments of the orchestra, where it too often does duty for the orchestral Trumpet, and does it badly. The CORNOPEAN, 8 FT., should certainly never occupy the place of the TRUMPET in any Organ. In strength of tone or general assertiveness the CORNOPEAN should occupy a place midway between the TRUMPET and the normal HORN, 8 FT., in the Organ; accordingly the CORNOPEAN is only called for in large tonal appointments.

It has long been the ambition of reed voicers to produce a stop, the tones of which would closely imitate those of the orchestral Horn. Many attempts have been made to produce the peculiar and melancholy character of the tones produced by the *closed sounds* of the orchestral instrument, but until quite lately no marked success has attended these praiseworthy attempts. We have before us as we write a newly-invented striking-reed pipe, which is more strictly imitative in its tone than any specimen of reed voicing of the class that has come under our notice. Of this pipe we shall speak fully farther on.

The normal HORN, 8 FT., as found in modern Organs, can lay no claim to have an imitative voice. It has simply a comparatively soft and smooth intonation in best examples; of the inferior examples it is unnecessary to speak. The resonators of the pipes are similar to those of the TRUMPET, but are usually of larger scale. The tones produced should be of a softer and smoother character than those of the CORNOPEAN, as above described. Several expedients have been resorted to, to approach the *closed sounds* of the orchestral Horn, one of which consists of inserting within the resonator a disc of metal perforated with numerous small holes. This to some extent muffles the tone natural to the pipe, but in no way improves it. In other examples the resonators are partly closed at top, or are furnished with adjustable shades, which allow the pipes to be regulated and slightly modified in tone. The reeds should be of the closed class, and their openings should be somewhat smaller than those of the CORNOPEAN. The tongues should be of good substance and have the slightest curvature consistent with the production of a prompt and satisfactory tone. In making these remarks, we have in mind a stop widely different from the HORN of the ordinary organ builder and pipe maker, which has often a more powerful voice than a good CORNOPEAN.

Mr. Ernest M. Skinner, of Boston, Mass., has recently invented a striking-reed HORN, 8 FT., the resonators of which depart widely both in form and proportions from those which have hitherto been supposed proper for the HORN of the modern Organ. Instead of the resonators being simply inverted conical in form and of large scale, after the TRUMPET model, they are extremely slender and, accordingly, only very slightly tapered, and have at top a cylindrical portion carrying

an adjustable slide shaded with a disc of metal, one half of which can be raised to any required extent in the process of tonal regulating. We have before us as we write a tenor C pipe of this remarkable HORN, from which the illustrations given in Fig. CCCLII. have been accurately executed to scale. The dimensions of the tongue are: Length from under side of block $2\frac{3}{16}$ inches; width at free end $\frac{7}{16}$ inch; and width where it is wedged into the block $\frac{7}{32}$ inch. It is comparatively thick and slightly curved. The resonator is 3 feet $3\frac{1}{2}$ inches long from the upper surface of the block, and its internal diameter is 1·63 inches. In Diagram 1, Fig. CCCLII., the form of the entire pipe is shown in correct proportions. In Diagram 2 is given a Longitudinal Section of the sound-producing portion of the pipe drawn to scale. In the section of the reed it will be observed that its opening does not extend down to the closed end. The position and form of the opening in the face of the reed are accurately shown in the Front View of the reed given in Diagram 3. In Diagram 4 is shown the treatment of the upper part of the resonator with its adjustable and shaded cap. While extremely slender resonators have frequently been employed in the construction of the pipes of the ORCHESTRAL OBOE and FAGOTTO, we have never met with them, outside the present instance, in a stop of the HORN species. This simple fact points out how desirable it is that those skilled in reed-pipe construction and voicing should extend their studies beyond the every-day methods which obtain. There is much to be done in reed-work that will repay all the time and labor that it may exact. Mr. Skinner's achievement is an eloquent proof of this. It is safe to say that no more acceptable addition to the tonal forces of the Concert-room Organ can be conceived than a truly imitative ORCHESTRAL HORN, 8 FT.

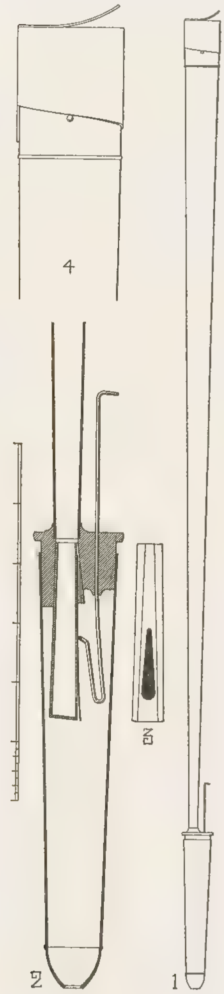


FIG. CCCLII.

CLARION.—This stop is in its normal form simply an OCTAVE TRUMPET, 4 FT. Its pipes are, in construction and general treatment, precisely similar to those of the TRUMPET, 8 FT. While the latter stop is invariably carried throughout in reed pipes, the CLARION, 4 FT., owing to its high pitch, usually has its top octave of large-scale and loud-toned labial pipes. The tone of the CLARION should in all artistic tonal appointments be subordinate to that of the associated TRUMPET. Its resonators should, accordingly, be of smaller scale. In all ordinary cases it should have closed reeds. When the TRUMPET is harmonic, it is usual and proper, although not absolutely essential,

to have a Harmonic Clarion, 4 ft. The Clarion, when properly voiced and regulated, is a very valuable addition to the reed-work of the Organ, brightening it, and materially enriching its harmonic structure. The stop is, however, rarely introduced in small Organs, where its high-pitched voice would be almost certain to upset the tonal balance.

Double Trumpet.—This stop is an unimitative Trumpet, of 16 ft. pitch, frequently introduced in the Great divisions of large Organs. It is, however, best suited for the most important expressive division, where its grave and commanding voice would be under control and productive of fine effects. When associated with the unison Trumpet, its voice should be somewhat subordinate, so as to disturb as little as possible the unison pitch. For this purpose, the scale of its corresponding pipes should be smaller than that of the Trumpet, 8 ft., pipes. The form and construction of the pipes of the Double Trumpet are identical with those of the unison Trumpet, and, accordingly, do not call for special description and illustration.

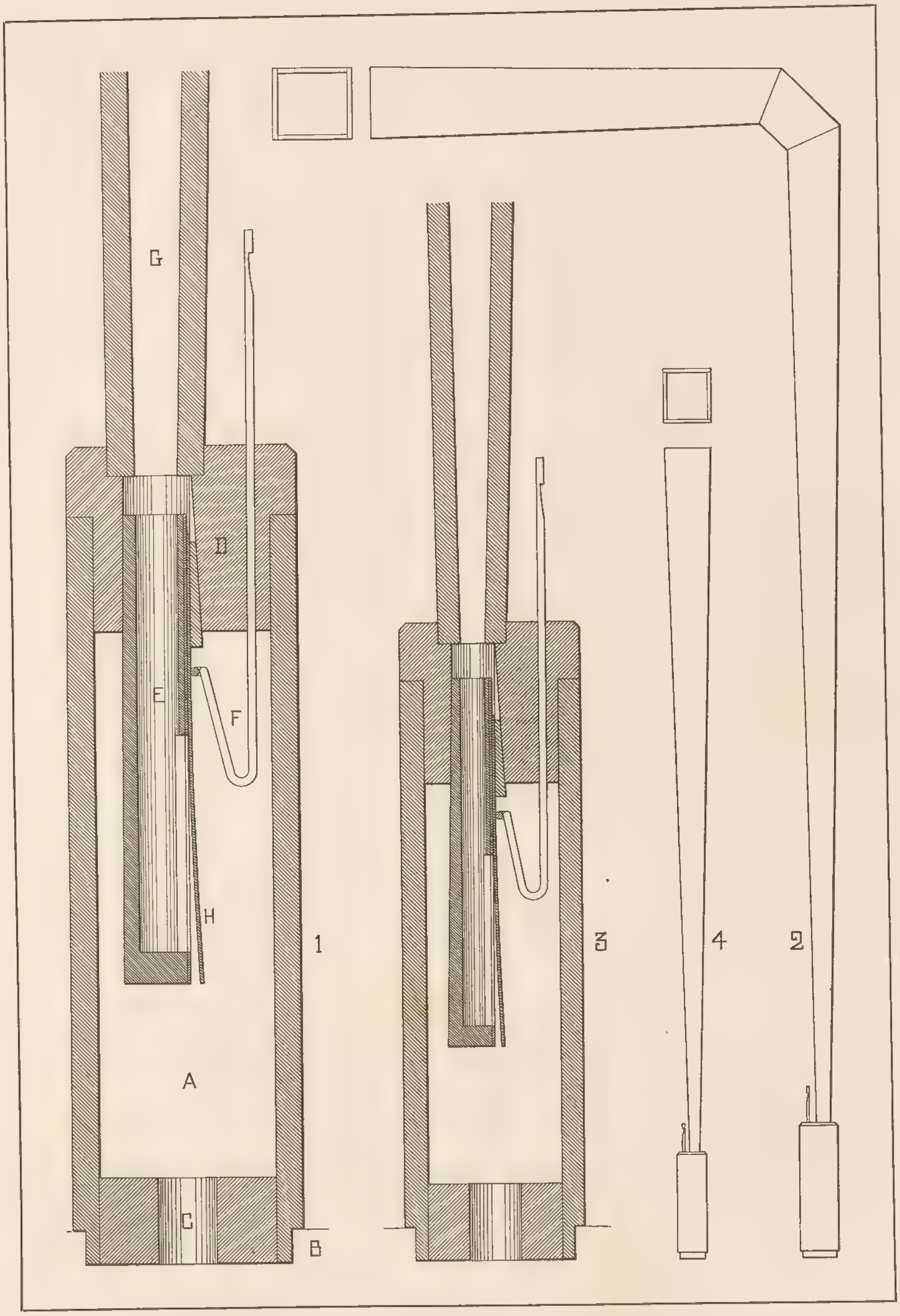
Trombone or Posaune.—This stop belongs to the Trumpet family. When introduced in a manual division, it is properly of 8 ft. pitch and constructed entirely of metal, differing from the ordinary Trumpet, 8 ft., only in having tongues and reeds of more powerful and distinctive intonation and resonators of larger scale. Its tone should closely imitate that of the orchestral Trombone, having the brazen clang of that instrument when played *forte*. This *timbre* distinguishes the Trombone, 8 ft., from the other unison reeds of the same family—Trumpet, Tuba, Cornopean, and Horn—in which brassy tonality is objectionable. The Trombone of the Pedal Organ is properly of 16 ft. pitch, and is constructed entirely of metal or of wood and metal. When of metal, its pipes differ in no respect beyond their size from those of the Trombone, 8 ft. When chiefly of wood, the pipes differ considerably both in form and mode of construction. It will be sufficient for us to describe the CCC and CC pipes of a Pedal Organ Trombone, 16 ft., made by Roosevelt. In Plate IX. are given Transverse Sections of the sound-producing portions of these pipes, accurately drawn to scale, and Side Views of the complete pipes, showing the proportions of their resonators. At A, in Diagram 1, is a Longitudinal Section of the boot of the CCC pipe, a quadrangular box of wood 16 inches long and measuring internally 3½ inches by 2⅞ inches. Its lower end is socketed into the upper-board of the windchest B, and is supplied with pipe-wind through the hole C, 1⅛ inches in diameter. The upper end of the boot receives the hardwood block D, bored for the reception of the reed E and the passage of the tuning-wire F, and socketed to receive the lower end of the resonator G. The reed E is made of maple, turned, bored, plugged at its lower end, and planed so as to provide a face for the tongue H to strike against. The face is covered throughout the greater portion of its length with close-grained leather, faced with smooth drawing-paper of the finest quality, while its upper portion, against which the tuning-wire presses the tongue, and which enters the block, is covered with a veneer of hardwood, of exactly the same thickness as the leather, over which the paper facing is carried. The leather and veneer are indicated in the diagram between the reed and the tongue.

The tongue is of hard rolled brass, about $\frac{1}{32}$ inch thick, $6\frac{7}{8}$ inches long from the under surface of the block, $\frac{13}{16}$ inch wide where it is wedged into the block, and $\frac{15}{16}$ inch wide at its free end. The resonator is of pine, quadrangular and inverted pyramidal in form, having a speaking length of 14 feet 1 inch, and an internal size at top of $8\frac{3}{8}$ inches by $7\frac{1}{2}$ inches. In Diagram 2 is shown, also in correct scale, a Side View of the complete CCC pipe. In Diagram 3 is given a Longitudinal Section of the sound-producing portion of the CC pipe, drawn to the same scale as Diagram 1. Its dimensions are as follows: Length of boot 10 inches, and internal measurements of same $2\frac{5}{8}$ inches by $2\frac{3}{16}$ inches; diameter of wind-hole $\frac{11}{16}$ inch; length of tongue from under surface of block $5\frac{1}{8}$ inches; width of tongue at wedge $\frac{19}{32}$ inch, and at its free end $\frac{11}{16}$ inch; length of resonator 7 feet, with an internal size at top of $5\frac{3}{8}$ inches by $4\frac{7}{8}$ inches. In Diagram 4 is shown a Side View of the complete CC pipe drawn to the same scale as Diagram 2. As the sound-producing portion of the CC pipe is of precisely the same construction as that of the CCC pipe it is unnecessary to go into further particulars respecting it. The stop composed of pipes constructed as above described is very suitable for a Pedal Organ of small dimensions, in which it would be the only reed. Its tone is dignified and full, in which the brazen character properly belonging to the manual TROMBONE, 8 FT., is desirably absent. The smoothness of intonation is due to the manner in which the reeds are made and leathered and the fine curvature of the strong tongues. In addition, the large size of the boots favors the production of smooth and prompt speech. When incorrectly made and badly voiced, as one frequently finds it in cheap Organs, the TROMBONE, 16 FT., is an abomination without one redeeming feature.

CONTRA-TROMBONE.—This name is employed to designate a TROMBONE, 16 ft. pitch, inserted in the manual department, the tone of which is intended to imitate that of the Bass Trombone of the orchestra; and also to designate a stop of similar character and of 32 ft. pitch, inserted in the pedal department of the Organ. The manual CONTRA-TROMBONE should be constructed entirely of metal, its resonators being made of stout zinc topped with good pipe-metal. Its true tone should resemble that of the TROMBONE, 8 FT., as above described, but be slightly softer. The CONTRA-TROMBONE, 32 FT., of the Pedal Organ, should be similar in tone to the TROMBONE, 16 FT., and be constructed in precisely the same manner.

Certain English organ builders have used the name CONTRAPOSAUNE for stops having a more powerful and a more brazen tonality than those commonly designated by the name CONTRA-TROMBONE; but in the present unsatisfactory state of organ-stop nomenclature in both England and America, very little weight can be laid on the names used by organ builders, so far, at least, as fine distinctions of tonality are concerned. Even a brief survey of the tonal appointments and the stop-knobs of English and American Organs may well cause one to ask: "What's in a name?"

OPHICLEIDE.—The tone of this stop is intended to imitate that of the orchestral Ophicleide, but the imitation is far from satisfactory. The OPHICLEIDE of the Organ is an extremely powerful, high-pressure reed, of 8 ft. pitch in the manual department, and of 16 ft. pitch in the Pedal Organ. The resonators of the pipes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are inverted conical in form, of large scale, and constructed of thick spotted metal or of zinc and pipe-metal, while the reeds and tongues are made to withstand the action of wind of very high pressure. Otherwise, the construction of the pipes differs in no essential from that of the pipes of the TRUMPET or the TUBA. In the Willis Organ in St. George's Hall, Liverpool, there are two OPHICLEIDES, of 8 ft. pitch, in the manual department, and one, of 16 ft. pitch, in the Pedal Organ. The fine unison stop in the Solo Organ speaks with a commanding voice on wind of 22 inches pressure: this is, so far as our knowledge extends, the grandest specimen of the organ OPHICLEIDE, 8 FT., in existence—voiced by a master hand.

Having outlined the forms and construction of the pipes of all the important stops belonging to the TRUMPET family, which are introduced in modern Organs, and which in their tones imitate to some extent the characteristic voices of the brass wind instruments of the orchestra, exclusive of the Saxophones, we may now direct attention to the forms and construction of the pipes of the stops whose tones more or less closely imitate those yielded by the reed instruments of the orchestra, the chief of which remain in use to-day.

OBOE.—Though rarely successful so far as imitative tone is concerned, the OBOE, 8 FT., is the reed stop most frequently introduced in Organs of all dimensions. In small instruments it is often the only reed stop inserted: and when it is so, its tone is almost invariably of a bright, unimitative character, being what may be considered normal organ reed-tone. This character renders it generally useful for combination with labial stops of all tonalities. When carefully voiced and regulated, the unimitative OBOE is also very useful as a solo stop. The reeds of this stop are of a smaller scale than those of the normal TRUMPET, 8 FT., and are invariably of the closed class, having comparatively small triangular openings in their faces, which extend upward from the discs which close their lower ends. The tongues are correspondingly slender in form and of medium thickness, and have a slight and finely formed curve, which prevents the production of any coarseness or brassiness in the tone of the pipes. The bodies or resonators of the pipes of the OBOE now under consideration have each a slender tapered tube surmounted by a long inverted conical bell, imitating to some extent the conical and belled tube of the orchestral Oboe. In its most satisfactory construction, the resonator has its bell shaded with a disc of pipe-metal, soldered to the bell so as to allow about one half free to be bent up to any desirable extent in regulating the tone. Shaded OBOES are not invariably introduced, but they are unquestionably the most desirable tonally. The form of the OBOE pipe just described is shown in Diagram 1, Fig. CCCLIII., which represents a pipe belonging to the lower octaves of a stop. As the pipes become shorter, the relative proportions of their tubes and bells are considerably altered, so much so that in the highest octave the tubes and bells are about the same length. Some makers abandon the proper form of pipe in the highest octave of the stop and use simply inverted conical resonators, like those belonging to the TRUMPET. This labor-saving practice should certainly never be encouraged. It is not too much to say that unless the correct form of pipe is carried throughout a stop, a perfect uniformity of tonal character is impossible.

Orchestral Oboe.—Voicers realizing the utter impracticability of obtaining what Berlioz describes as the "small acid-sweet voice" of the orchestral Oboe—"especially a melodial instrument, having a pastoral character, full of tenderness"—from the form of pipe above described, numerous attempts have been made, with different forms and proportions of reeds, tongues, and resonators, to arrive at a close imitation of the characteristic tone of the true instrument. Probably the most successful results have been obtained by Willis, who adopted resonators of an extremely slender inverted conical form, devoid of bells, and having closed upper ends and elongated perforations adjoining them. This form of pipe is shown in Diagram 2, Fig. CCCLIII., which is derived from the Willis Orchestral Oboe, such as is to be found in the Organs in Durham Cathedral and the Town Hall of Huddersfield. Another example very similar in treatment exists in the Organ, by the same distinguished builder, in Glasgow Cathedral. In the last example the reeds are very small, and have their stopped ends formed at an acute angle upward from the lower edge of their faces. The tongues are very narrow and beautifully curved. Less successful stops have been formed of pipes having very slender tubes carrying small shaded bells, the latter being slotted or pierced with circular holes. In all cases the reeds are closed and of small diameter, and the tongues are thin and very narrow. In the construction of the pipes of this, and, indeed, of all delicate striking-reed stops, the open ends of the reeds, before they are inserted in their blocks, should be covered with very fine silk gauze, stretched over them and glued down on their sides. While this treatment in nowise impairs the tone, it prevents dust falling into the reeds and silencing them.

Fig. CCCLIII.

As the Oboe of the orchestra does not go below tenor B♭, it is obvious that the imitative tones of the Orchestral Oboe, 8 ft., of the Organ must stop at that note. Below B♭ the pipes should strictly be of the Fagotto class, because the true Fagotto provides the proper bass to the Oboe of the orchestra. But it is both unnecessary and undesirable to break the organ stop either in tone or in the form of its pipes. In purely Oboe solo passages, the performer will never be called upon to go beyond the correct compass of the instrument, while in ordinary organ music the complete stop will be extremely valuable in combination with the other tonal forces of the Organ. In the absence of a Fagotto, 8 ft., the lower octaves of the Oboe will be found invaluable for certain orchestral effects. The latter stop, on account of the short compass of its strictly imitative portion, has been frequently labeled Oboe & Fagotto.

The German and French organ builders frequently construct their Oboes with free reeds; but their tones are deficient in imitative character and lack brilliancy and individuality. To secure a certain thinness of tone, the free tongues are sometimes made narrower toward their vibrating ends—exactly opposite in form to the striking tongues. As absolutely nothing can be gained by using free reeds of any form for either the unimitative or imitative Oboe, and as they are never likely to be adopted by the organ builders of England and America, a further description would only be a waste of valuable space.

Contra-Oboe or Contra-Hautboy.—This stop, of 16 ft. pitch, is of course unimitative in its tone, carrying down the ordinary unimitative Oboe, 8 ft. Its general construction is similar in all essentials to that of the Oboe above described and its pipes are of the form shown in Diagram 1, Fig. CCCLIII. The stop is extremely rare; the only examples which have come under our observation are the Contra-Hautboy, 16 ft., made by Willis, in the Organ in St. George's Hall, Liverpool, and the Contra-Oboe, 16 ft., by the same builder, in the Organ in Royal Albert Hall, London. Fine as these stops are, we do not advocate stops of the same class for general adoption.

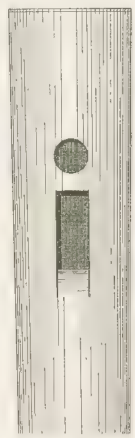


Fig. CCCLIV.

Fagotto.—In all Organs which contain imitative stops of an orchestral character, the Fagotto or Bassoon, 8 ft., is an absolute necessity. No Concert-room Organ can be considered complete in which the stop does not appear in the manual department. When artistically voiced, its tone closely imitates that of the orchestral Fagotto, while it is more uniform in color throughout. Its peculiar color renders it highly valuable in countless tonal combinations. The reeds and tongues of the Fagotto are essentially similar to those used for the Orchestral Oboe, but slightly larger in scale, giving a desirable fulness and solidity to the tone, to distinguish it from the characteristic voice of the Oboe. The resonators commonly used for the Fagotto are, when of metal, inverted conical in form; and when of wood, inverted pyramidal in form. We are strongly of opinion that the best tonal results are to be obtained from the resonators of wood. In all cases the resonators are of very small scale: in this respect approaching the conical tube of the orchestral Fagotto. While resonators open at top and provided with metal shades have been frequently employed, those completely closed at top and slotted or otherwise perforated near their closed ends have yielded the most satisfactory imitative tones. This latter treatment has been adopted by Willis in the pipes of some of his stops. In Fig. CCCLIV. is represented the upper portion of the resonator of the CC pipe of the Bassoon, 8 ft., inserted by Willis in the original Organ in Colston Hall, Bristol. The upper end, which is only 2 inches in diameter, is completely closed with a metal disc, soldered on. At a distance of 2⅛ inches below the top is pierced a hole ½ inch in diameter, and below this, at a distance of ¼ inch, is cut a slot ½ inch wide and 1⅝ inches long, provided with a small regulating piece cut from the slot, all as

clearly indicated in the illustration. We found the tone of this stop very quiet and refined, but lacking somewhat in the reediness characteristic of the tones of the orchestral Fagotto. This is a fault that could have been easily rectified by an alteration in the curvature of the tongues. A beautiful smoothness has always characterized the Willis reed stops of the best period. Such a FAGOTTO as we have just spoken of would be an admirable voice in a true Chamber Organ.

FIG. CCCLV.

The wooden tubes or resonators of the FAGOTTO pipes are properly square in transverse section, and must be made of sufficient thickness to withstand the vibrations of the columns of air within them. Their lower ends should be rounded externally so as to fit into the metal socket pieces soldered to the reed-blocks; and they must be bored vertically with holes corresponding in size to the reeds below. These holes will open into the interiors of the resonators, and die out as the latter expand in size. The resonators may be simply shaded by adjustable metal plates; they may be both shaded and slotted; or they may be closed at their upper ends and slotted after the fashion of the metal resonator shown in Fig. CCCLIV. A really fine FAGOTTO, 8 FT., having a rich and clearly-marked imitative tone, will be an artistic treasure in any Organ.

CONTRAFAGOTTO or DOUBLE BASSOON.—This is a stop, of 16 ft. pitch, formed in all respects like the stop just described. In its only proper form it yields tones imitative of those of the orchestral Contrafagotto. Its resonators should be made of wood when there is sufficient room for their accommodation; but when mitering is necessary, the resonators are properly made of metal. The CONTRAFAGOTTO, 16 FT., is both a manual and a pedal stop. When placed in the Pedal Organ, its tone should be as powerful as its imitative character warrants: and when placed in the manual department, its voice should be of medium strength, and it should invariably be inserted in an expressive division.

CLARINET.—This is one of the most important reed stops of the Organ; while it is, under favorable conditions, the most satisfactory of all in its orchestral or imitative tonality. The CLARINET, 8 FT., of the Organ when voiced by a master hand yields tones which reproduce with remarkable fidelity those of the best registers of the orchestral Clarinets. Speaking of the latter, Berlioz says: "*Single reed* instruments, such as the Clarinet and the Corno di Bassetto, form a family, whose connection with that of the Hautboy is not so near as might be thought. That which distinguishes it especially, is the nature of its sound. The middle notes of the Clarinet are more limpid, more full, more pure than those of *double reed* instruments, the sound of which is never exempt from a certain tartness or harshness, more or less concealed by the player's skill. The high sounds of the last octave,

commencing with c^3, partake only a little of the tartness of the Hautboy's loud sounds; while the character of the lower sounds [DD to e^1] approaches, by the roughness of their vibrations, to that of certain notes of the Bassoon." The compass of the orchestral Clarinets is from DD to d^4 inclusive, and including the lower notes of the Bass Clarinet, and is, accordingly, covered by the unison compass of the Organ, with the exception of the two highest and seldom-attempted notes. In voicing the CLARINET, the artist should take for his tonal model the middle register of the orchestral Clarinets. On $b\flat^1$ the register known as the *chalumeau* commences and extends downward, having a distinctive tonal coloring; but there is no necessity, we venture to think, for the organ stop to change its quality of tone on this or any other note. It is certainly open to the artistic voicer to carry his imitations to any degree of nicety he may think proper, and we would be the first to commend him for so doing.

The CLARINET pipe differs in form and proportions from all those previously described and illustrated. This will be clearly seen on glancing at Fig. CCCLV., which represents a CC pipe, or that yielding a note of 8 ft. pitch. The resonator, instead of being, approximately, the true speaking length of eight feet, is in this case only a little more than four feet in length above the reed-block. The resonator is cylindrical except where it is coned to adapt it to the size of the hole in the block in which the reed is inserted. To this form of resonator is mainly due the imitative character of the tone produced, resembling as it does the cylindrical tube of the orchestral Clarinet, which has the same series of upper partial tones as a stopped labial pipe. Both in the lengths and scale of its resonators the CLARINET differs from all the reed stops belonging to the other families. The following Table of measurements, obtained from a very beautiful CLARINET, 8 FT., made by a distinguished English artist, fully supports what we have just stated:

SCALE OF CLARINET, 8 FT.

PIPES.	DIAMETERS OF RESONATORS.	LENGTHS OF RESONATORS.	STANDARD LENGTHS OF OPEN LABIAL PIPES.
CC.	$1\frac{3}{4}$ inches.	4 ft. $3\frac{1}{2}$ inches.	8 ft. 0 inches.
C.	$1\frac{1}{4}$ "	2 " $1\frac{1}{2}$ "	4 " 0 "
c^1.	$1\frac{1}{8}$ "	1 " $1\frac{1}{4}$ "	2 " 0 "
c^2.	$\frac{15}{16}$ "	0 " $6\frac{5}{8}$ "	1 " 0 "
c^3.	$\frac{13}{16}$ "	0 " $3\frac{9}{16}$ "	0 " 6 "

The resonators of this stop are furnished with adjustable regulating slides, by means of which they can be slightly altered in length, so as to secure perfect uniformity in strength and character of tone throughout the compass. The form of the regulating slide is shown in Fig. CCCLV. This treatment is preferable to any method of shading. The scales adopted by different makers vary considerably, as may be seen by comparing the diameters given in the above Table with the following, derived from a CLARINET made by the late Mr. George Willis: c^1 pipe, diameter of resonator, $1\frac{3}{16}$ inches; c^2 pipe, $1\frac{1}{8}$ inches; and c^3 pipe, $1\frac{1}{32}$ inches. The lengths of the resonators are practically the same as those given in the

Table. The resonators which are of sufficient length to admit of being mitered should be so treated near their open ends, to prevent dust readily finding its way into the reeds. Under any circumstances the upper ends of the reeds may be covered with fine silk gauze. The reeds of the CLARINET are of medium size and invariably of the closed kind, their triangular perforations extending directly from the discs which stop their lower ends. These discs commonly slope upward from the faces of the reeds, but only to a small extent.

While the resonators of the CLARINET are at the present time invariably made of metal, they have in a few instances been formed of hardwood, cylindrical in form, and carried in metal sockets, which are soldered to the reed-blocks in the usual manner. These resonators can be made by boring and turning single pieces of wood; or they can be formed of two pieces glued together, each piece having exactly half the bore of the resonator worked in it. When glued together, the resonators can be turned in the lathe to the requisite thickness and size to fit their respective metal sockets. We are strongly of opinion that admirable resonators could be made of good tough paper, glued, and rolled around mandrels of the proper sizes. The tubes so formed can be rendered hard and durable, and quite unsusceptible to atmospheric influences, by being thoroughly saturated with shellac varnish, applied internally and externally.* Resonators so formed would have to be carried in metal sockets, as in the case of the wooden resonators above mentioned.

Organ builders in both Germany and France have long favored the adoption of free reeds for their CLARINETS, and also for certain other stops of the same family, such as the KRUMMHORN and CROMORNE. The tones of the free-reed CLARINETS, whatever the forms of their resonators may be, are not satisfactory imitations of those of the orchestral Clarinet; and in no respects equal the tones produced by the striking-reed stops made by the best English and American organ builders. In the free-reed stops different forms of resonators are used, the most common consisting of a conical body, surmounted by a short truncated cone carrying a regulating shade. This form somewhat resembles the resonator of the old KRUMMHORN pipe, shown in Diagram 4, Fig. CCCL., but without its top bell. In the Choir division of the Organ in the Church of St. Mary, East Parade, Bradford, Yorkshire, constructed by C. Anneessens, we found a free-reed stop labeled CLARINET À PAVILLON, the resonators of which are in the form of short inverted cones surmounted by shorter cylindrical pieces upon which are fitted regulating slides, shaded with partly-attached metal discs in the usual fashion. In one of the pipes we measured the conical body of the resonator is 4⅞ inches long, having a diameter at its cylindrical adjunct of 2 inches. This adjunct and the regulating slide measure 1 inch in height. The entire resonator has, accordingly, a speaking length of about 6 inches. The tone of this stop is pleasing but not a satisfactory imitation of that of the orchestral Clarinet; on the contrary, it inclines to the tone one attributes to the Musette. In the price list of August

* In the year 1887, Mr. Mark Wicks published a small work, entitled "Organ-Building for Amateurs" (Ward, Lock & Co., London), in which he fully describes the process of making paper pipes of all forms.

Laukhuff, the largest maker of organ pipes in Germany, we to-day find the free-reed CLARINET included among the stops regularly manufactured by him.

CORNO DI BASSETTO.—This fine stop belongs to the CLARINET family, and when made by a master hand is hardly equaled by any other reed stop of the Organ. The orchestral instrument from which it derives its name is practically a Tenor Clarinet furnished with a prolonged bore and additional keys, which give it a compass from FF to c^3. The tone of the Corno di Bassetto is fuller and more reedy than that of the Alto Clarinet, and, accordingly, the tone of the CORNO DI BASSETTO, 8 FT., should be richer and nobler than that of the CLARINET, 8 FT. To secure this desirable result, the reeds should be somewhat larger in their diameters and have longer perforations in their faces, and the tongues should be both wider and thicker than the corresponding parts of the pipes of the CLARINET. The resonators should also be of larger scale. While they are usually made cylindrical, like those of the CLARINET, we are of opinion that the addition of a small bell, surmounting the regulating slide, would considerably improve the tone. The most successful examples of the stop known to us are those made by Willis. One of these is in the Swell division of the Organ in St. George's Hall, Liverpool. In the Organ in Royal Albert Hall, London, we find two examples: one in the Choir and the other in the Solo division. Both are of 16 ft. pitch, and, accordingly, cannot be classed as imitative stops. In combination with the CLARINETS, 8 FT., in the same divisions they produce compound tones of remarkable character. In our opinion the value of the CORNO DI BASSETTO, 8 FT., cannot be overrated.

VOX HUMANA.—This is another stop belonging strictly to the CLARINET family, the chief peculiarity in its construction obtaining in the shortness of the cylindrical resonators of its pipes. The resonators are in the best examples of the stop only about half the length of those of the CLARINET; and, accordingly, are approximately one-fourth the length of open labial pipes yielding tones of the same pitch. The strained relations which exist between the reeds and the resonators create a tone of false character, which is generally accepted as imitating the human voice, the slight resemblance to which is increased by the addition of a *tremolo* effect. The finest VOX HUMANA that has come under our observation, and one that did not require distance to lend enchantment to it, was a perfect stop of refined tone, which could be used in full chords, alone or in combination, when the Tremolant was not drawn with it. It was about as imitative of a human voice as one could possibly expect from organ pipes, when a slow and delicate *tremolo* was imparted to its sounds. Such a VOX HUMANA is widely different in its construction and tone from the much-vaunted stops of the same name in certain European Organs, and notably in the Organ of Lucerne Cathedral, the sole beauty of which consists in their being located so far away from the ear of the listener, and so ameliorated by existing acoustical conditions, that they can be tolerated. Such stops when heard in their immediate neighborhood are coarse and vulgar in the extreme. It is extremely rare to find a VOX HUMANA, 8 FT., having anything approaching a rich and refined tone in an English or American Organ; even the great Willis has not scored a marked success in this direction. The VOX HUMANA which we have alluded to as the finest which has come under our observation was

made by Mr. E. Franklin Lloyd, of Liverpool. The resonators of this stop have a different treatment from those we have found in the other Vox Humanas we have examined. In Diagram 1, Fig. CCCLVI., is represented the middle c^1 pipe of this stop, accurately drawn to scale. The resonator is completely closed at top, and is slotted close to its upper end, as indicated in Diagram 2. The effective length of this slot is determined by the regulating slide A, which is made of tin-plate sprung tightly around the resonator. This form of resonator produces a fuller and more refined tone than seems possible to be obtained from the ordinary open-topped and shaded forms. The common type of Vox Humana pipe is illustrated in Diagram 3, Fig. CCCLVI. Stops composed of such pipes invariably require the refining effect of distance and more or less inclosure. In the case of the Lloyd Vox Humana, above spoken of, the tone was perfectly agreeable, with or without the addition of the *tremolo*, at a distance of ten feet, and while speaking in an open swell-box, and under no special acoustical conditions.

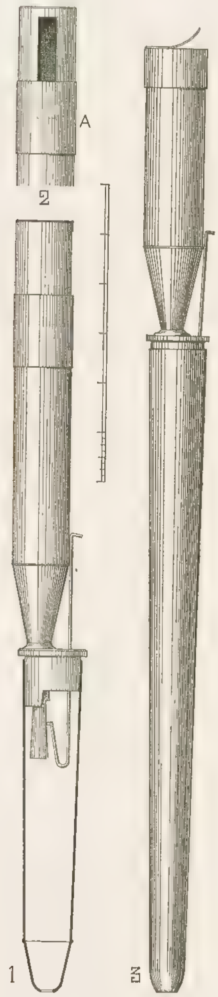


Fig. CCCLVI.

The reeds of the Vox Humana are closed, of medium size, and are pierced with very narrow triangular openings. The reed of the middle c^1 pipe usually measures about $1\frac{3}{8}$ inches in length from the under surface of its back, having a diameter at its lower end of about $\frac{13}{32}$ inch. The tongue of this reed at its free end seldom exceeds $\frac{1}{4}$ inch in width, and is very thin and slightly curved. The largest tongue, that of the CC pipe, seldom exceeds $\frac{11}{32}$ inch in width. In the reeds of some makers the triangular openings start from the plates which are soldered to their ends, while in those of other makers the openings start a short distance above their stopped ends, as in the reeds of the Horn, illustrated in Fig. CCCLII. We are in favor of this latter treatment, which has unquestionably an influence toward refinement of tone, a virtue which the average Vox Humana is markedly innocent of. The boots of Vox Humana pipes vary greatly in their lengths. While no boot in the Lloyd stop measured more than 7 inches in length, we have before us as we write a middle c^1 pipe the boot of which is $20\frac{1}{2}$ inches long. An example of a long boot is given in Diagram 3, Fig. CCCLVI.

Other forms of resonators than those we have mentioned and illustrated have been tried for the pipes of the Vox Humana, but little success has apparently

attended them; perhaps the most satisfactory of these have cylindrical bodies surmounted by short truncated cones, having openings at top of about half the diameters of their respective bodies; or have their cylindrical bodies furnished with regulating slides covered with discs of metal, soldered on, and pierced with holes in their centers for the emission of sound. Alluding to the several forms of resonators and to the stop in general Max Allihn remarks:

> "Vox Humana and Vox Cœlestis are intended to imitate the human voice, which will only be possible when the stops occupy a distant and covered place within a large instrument in a large room. . . . The blocks and tongues correspond to those proper for an 8 ft. stop of large scale and delicate intonation, but the bodies of the Vox Humana pipes are of quite different proportions and form. Definite measurements or forms do not exist. Every organ builder follows his own predilection and experience. Some use short cylindrical bodies, closed at top with the exception of a small opening; others make larger bodies with larger openings; while others prefer conical bodies closed with the exception of a small lateral opening. All treatments are alike in that the bodies are more or less covered."

In the above remarks the writer is alluding to the free-reed Vox Humana, a stop which is practically obsolete to-day.

FREE-REED STOPS.

In the early pages of the present Chapter and in our remarks on reed pipes in our Chapter on Acoustical Matters Connected with Organ Pipes, we have briefly described the construction of striking-reed pipes; and we have now to give an equally brief outline of the formation of free-reed pipes. As we have already pointed out, the tongues of the former class of pipes *strike* against the exterior faces of the reeds at each vibration; hence the name given to distinguish the pipes in which they are used. In free-reed pipes, on the other hand, the tongues vibrate freely within openings provided for them, and come in contact with nothing while vibrating; hence the term *free*, employed to distinguish the pipes in which such tongues are used. Since the opening decades of the nineteenth century free-reed stops have been continuously introduced in German and French Organs, while it is only during comparatively late years that they have appeared in English and American Organs; and in all cases of their introduction they were imported from Germany or France. We think it is quite safe to say that no English organ builder ever made a free-reed stop; and the Organs in England in which free-reed stops are to be found can be counted on the fingers of one hand. We know that the late Mr. Hilborne L. Roosevelt made some very fine free-reed stops,—one of which he presented to us, for our own Chamber Organ, in the year 1885,—but we are not aware of any other American builder having given attention to the manufacture of such stops. To the great success which has characterized the English school of reed-voicing is probably due the almost total neglect of free-reed stops by English builders; but to this cause must be coupled their great reluctance to embark on methods new to them, and, accordingly, attended with uncertainty and more or less trouble. There is no question that the formation of satisfactory free-reed work

calls for a much higher class of workmanship than is necessary in the manufacture of striking reeds.*

The sound-producing portion of the free-reed pipe comprises a reed, a perforated reed-plate, a tongue, and a tuning appliance; the reed being either a portion of the block, or a separate part firmly inserted therein. The reed is a cylindrical tube of brass or hardwood, stopped at its lower end, and having a segment removed along the greater portion of its length for the reception of the perforated reed-plate or reed-frame. At A and B, Fig. CCCLVII., are shown a Front View and Transverse Section of a brass reed prepared to receive its reed-plate. The reed-plate is a straight piece of thick sheet or cast brass, perforated with an oblong opening for the reception of the free tongue, above which is a transverse channel for the accommodation of the under bar of the tuning appliance. At C, D, and E are shown a Front View, Longitudinal Section, and Transverse Section of the finished plate.

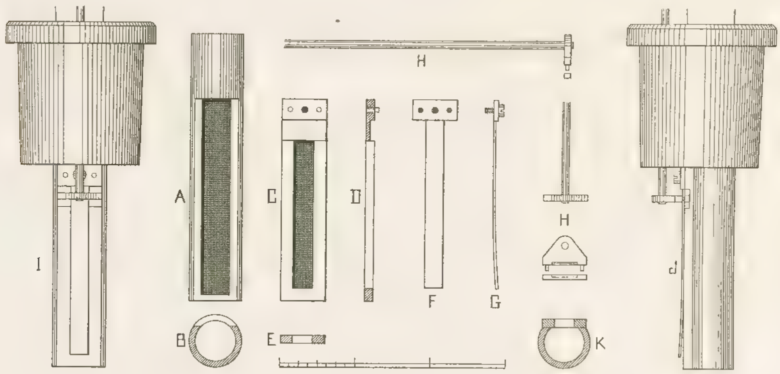


Fig. CCCLVII.

The plate is soldered to the reed, completing the same. The tongue is a piece of hard rolled brass cut in the form shown at F, the vibrating portion being reduced by filing to the requisite thickness, and slightly curved outward after the manner indicated at G. The tongue is firmly screwed, through its upper shoulder-piece, to the reed-plate, being held in correct position by means of two pins, indicated in the diagrams. The tuning appliance consists of three pieces of brass; namely, a long and stout wire, which passes downward through the block; a tuning-plate, firmly riveted to the lower end of the wire; and a small under bar of brass, which is placed under the tongue, and is connected with the tuning-plate above the tongue by two small lateral pins. The several parts of this tuning appliance are shown at H. Front and Side Views of the sound-producing portion of the free-reed pipe, in which all the parts above described are shown in their proper relation-

* The free-reed work of the stop presented to us by the late Mr. Hilborne L. Roosevelt is finished throughout as finely and accurately as the brass work of an expensive microscope or a surveying instrument.

ship, are given at I and J. The metal block to which the reed is firmly fixed is also shown. K is a Transverse Section of the reed with the reed-plate attached in proper position. In certain free-reed pipes, and notably those of deep pitch and large scale, both the reeds and blocks are turned or otherwise formed out of some close-grained hardwood. It was Roosevelt's practice, as a sample pipe before us shows, to turn both the block and reed out of a single piece of wood, thereby preventing any possibility of the reed becoming loose. When wooden reeds are used, the brass reed-plates are bedded on cloth and firmly screwed to them. This practice has been largely followed by the German free-reed pipe makers. In some instances these able artisans have abandoned both wooden blocks and reeds, screwing the reed-plates directly to the smaller ends of the inverted pyramidal wooden resonators of certain stops, sinking the ends so mounted into large quadrangular wooden boots. Such a treatment has advantages which should not be overlooked by those interested in free-reed work.

The boots of free-reed pipes, while they vary considerably in size in the works of different makers, are invariably much larger than those required and commonly used for striking-reed pipes. Large boots containing considerable volumes of air have been found by practical experience to be conducive, if not absolutely necessary, to the prompt and satisfactory speech of free reeds, but the reason for this has not been settled beyond question. An example of the employment of very large boots is furnished by the Pedal Organ CONTRA-SAXOPHONE, 16 FT., presented by the late Mr. Hilborne L. Roosevelt to the writer. As the dimensions of the boots and resonators of this fine stop may be of value for reference, we give those of certain pipes in the following Table:

EXTERIOR DIMENSIONS OF BOOTS AND RESONATORS—ROOSEVELT CONTRA-SAXOPHONE, 16 FT.

PIPE.	LENGTH OF BOOT.	WIDTH OF BOOT.	DEPTH OF BOOT.	LENGTH OF RESONATOR.	TOP DIAMETER OF RESONATOR.
CCC	$48\frac{1}{4}$ ins.	$3\frac{3}{4}$ ins.	$4\frac{3}{4}$ ins.	10 ft. $1\frac{1}{4}$ ins.	5·63 ins.
FFF	$37\frac{5}{8}$ "	$3\frac{1}{4}$ "	$4\frac{1}{8}$ "	7 " $7\frac{1}{4}$ "	5·00 "
CC	$23\frac{7}{8}$ "	$2\frac{13}{16}$ "	$3\frac{1}{2}$ "	5 " 1 "	4·13 "
FF	$19\frac{1}{16}$ "	$2\frac{5}{8}$ "	$3\frac{1}{4}$ "	3 " $9\frac{1}{4}$ "	3·56 "
C	$13\frac{3}{4}$ "	$2\frac{5}{16}$ "	$2\frac{3}{4}$ "	2 " $5\frac{1}{4}$ "	3·06 "
F	$11\frac{7}{8}$ "	$2\frac{3}{16}$ "	$2\frac{9}{16}$ "	1 " $9\frac{1}{2}$ "	2·75 "

From the above dimensions a correctly-graduated scale can readily be formed. The quadrangular boots of this stop are carefully constructed of white pine, having sides varying in thickness from $\frac{9}{16}$ inch in the largest to $\frac{5}{16}$ inch in the smallest pipes. The reed-blocks are of solid black walnut, and have the brass frames, carrying the free tongues, firmly screwed to them. The lower ends of the boots are plugged with slices of the same wood, into which the short pipe-feet are inserted. The boots of free-reed stops in the manual department are commonly cylindrical,

formed of stout zinc, having slightly spreading pieces for the reception of the reed-blocks, and tips of good pipe-metal. While such boots may not be of large diameter, they are almost invariably made of considerable length.

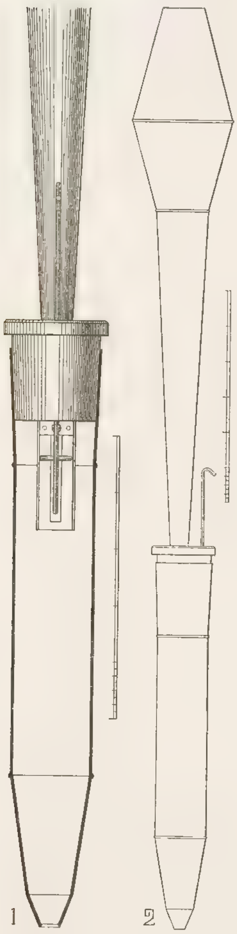


FIG. CCCLVIII.

The resonators of free-reed pipes are made of several shapes and proportions, and in these respects commonly differ from the resonators of striking-reed pipes, such as have been described and illustrated in the preceding pages of the present Chapter. It would seem that the field for investigation and experiment in connection with tone production in free-reed pipes, as influenced by the forms of resonators, is still open and bids fair to be interesting and profitable. The following particulars respecting the few free-reed stops made at the present time by European firms may point the way to further developments, and the addition of some valuable voices to the Organ.

COR ANGLAIS.—Of all the free-reed stops at present introduced in the Organ that known as the COR ANGLAIS or CORNO INGLESE may be considered the most satisfactory in its imitative character. The Cor Anglais of the orchestra is a double-reed instrument belonging to the Oboe family; indeed, it has commonly been classed as the Alto of the Oboe, and was sometimes called Oboe da caccia. The compass of the instrument is from E to b^2 inclusive; accordingly, the true imitative portion of the organ COR ANGLAIS, 8 FT., lies in this range. Speaking of the Cor Anglais, Berlioz remarks: "Its quality of tone, less piercing, more veiled, and deeper than that of the Oboe, does not so well as the latter lend itself to the gaiety of rustic strains. Nor could it give utterance to anguished complainings; accents of keen grief are almost interdicted to its powers. It is a melancholy, dreamy, and rather noble voice, of which the sonorousness has something of vague, — of *remote*, — which renders it superior to all others, in exciting regret, and reviving images and sentiments of the past, when the composer desires to awaken the secret echo of tender memories." To the reed voicer who has not had any opportunity of studying the tone of the orchestral instrument—now very rarely seen or heard—the above particulars will be helpful and interesting.

In Fig. CCCLVIII. are given drawings to scale, of a COR ANGLAIS middle c^1 pipe as made to-day by Mr. August Laukhuff, of Weikersheim, Württemberg, whose free-reed pipes are characterized by perfect finish, as the several examples

before us show. In Diagram 1 the boot is shown in longitudinal section; and the block, reed, tongue, tuning-wire, and lower part of resonator are shown in front view. In Diagram 2 an outline drawing of the entire pipe is given. The following are the principal dimensions of this c^1 pipe: Length of boot 10⅛ inches; diameter of boot $1\frac{7}{16}$ inches; full length of vibrating portion of tongue 1·50 inches; width of tongue 0·18 inch; length of resonator from top of reed-block 15⅜ inches; length of body 9½ inches; diameter of body at block ⅝ inch; diameter at junction with head $1\frac{9}{16}$ inches; height of lower, inverted cone of head 2½ inches; diameter at junction of cones of head $2\frac{13}{16}$ inches; height of top cone 3⅜ inches; and diameter of top opening of resonator 1⅛ inches. The dimensions of the resonators vary considerably; for instance, that of the middle c^1 pipe of the COR ANGLAIS, 8 FT., in the Organ in the Public Halls, Glasgow, measures 11¾ inches in length above block. Its head, formed of double, truncated cones, is only 3¼ inches long, having its largest diameter 1⅞ inches, and its junction with the body and its top opening 1 inch in diameter. In the following Table are given the principal dimensions of the five C pipes of the COR ANGLAIS, 8 FT., in the Organ in the Town Hall, Leeds, Yorkshire. The measurements were taken as accurately as practicable directly from the respective pipes.

COR ANGLAIS IN THE ORGAN IN THE TOWN HALL, LEEDS.

PIPE.	LENGTH OF BODY OF RESONATOR.	LENGTH OF HEAD OF RESONATOR.	LARGE DIAMETER OF HEAD.	SMALL DIAMETER OF HEAD.	LENGTH OF TONGUE.	WIDTH OF TONGUE.
CC	$18\frac{7}{8}$ ins.	6 ins.	3·25 ins.	1·63 ins.	2·31 ins.	0·25 in.
C	$12\frac{7}{8}$ "	4 "	2·63 "	1·38 "	1·50 "	0·22 "
c^1	$8\frac{5}{8}$ "	$3\frac{1}{4}$ "	2·13 "	1·13 "	1·13 "	0·19 "
c^2	$5\frac{3}{8}$ "	$2\frac{1}{4}$ "	1·69 "	0·94 in.	0·72 in.	0·17 "
c^3	$3\frac{3}{16}$ "	2 "	1·38 "	0·81 "	0·50 "	0·15 "

The proportions of the tongues of the COR ANGLAIS vary considerably in the works of different makers; an instance of this fact is furnished by two pipes in our possession; namely, the one already spoken of, made by Laukhuff, and another made by Roosevelt. In the former, the free vibrating portion of the tongue when tuned measures 1·05 inches in length by 0·18 inch in width, while the corresponding portion of the tongue of the Roosevelt pipe measures 0·98 inch in length by 0·33 inch in width. While both the tongues are very thin, that of the Roosevelt reed is the thinner of the two. Both tongues are very slightly curved.

The satisfactory imitation of the sonorous, dreamy, noble voice of the orchestral Cor Anglais would be an achievement any voicer might well be proud of, for it is questionable if the best possible imitation has been arrived at. While it is probable that the free reed is the most suitable for the production of the smooth dreamy voice of the true instrument, it is self-evident that very much depends on the form and proportions of the resonator. The form of resonator at present adopted, having its head constructed of two truncated cones and attached to a

slender inverted conical body or tube, has a slight resemblance to the bore and bell of the orchestral instrument. Its short length and somewhat large head seem necessary in connection with the free reed; but a closer approximation to the relative proportions of the bore and bulbous bell of the true Cor Anglais in the formation of the resonator, and the adoption of a striking reed therewith, would, in our opinion, prove successful tonally. Such striking-reed pipes would certainly present no difficulties in their construction.

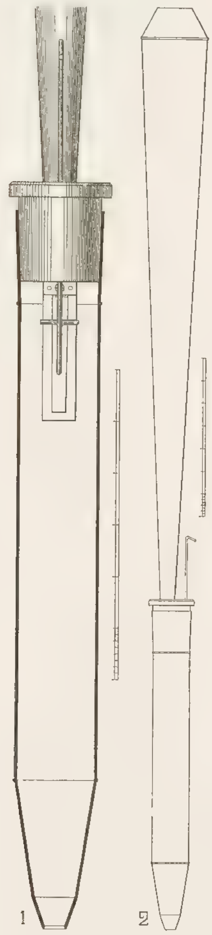


Fig. CCCLIX.

Euphone or Euphonium.—This is another stop made with free reeds at the present time. Its tone is intended to imitate that of the true Euphonium, but the imitation falls far short of what is desirable. However, the Euphone, 16 ft., as constructed by the best makers, is a fine and extremely valuable stop, especially for the pedal department of the Chamber Organ, in which roughness of intonation is most objectionable. The Euphone, as made by the late Mr. Hilborne L. Roosevelt, has resonators of inverted conical shape, similar to, but shorter and smaller in scale than, those of the corresponding pipes of the Double Trumpet, 16 ft. Other makers have used resonators of inverted conical shape surmounted by some shading or contracting device, preferably a short truncated cone. This latter form of resonator is adopted by Mr. August Laukhuff, as will be seen in Fig. CCCLIX., in which are drawings, accurately made to scale, of a C (4 ft. pitch) pipe of his Euphone, 16 ft. In Diagram 1 the boot is shown in longitudinal section; and the block, reed, tongue, tuning-wire, and lower part of resonator are shown in front view. In Diagram 2 an outline drawing of the entire pipe is given. The following are the principal dimensions of this C pipe: Length of boot 13¾ inches; diameter of boot 1⅝ inches; full length of vibrating portion of tongue 2·25 inches; width of tongue 0·27 inch; full length of resonator from top of reed-block 25¾ inches; height of truncated cone at top of resonator 1¼ inches; diameter of resonator at block $\frac{11}{16}$ inch; diameter at junction of cone 2⅞ inches; and diameter of top opening 1½ inches. German pipe makers adopt the same form of resonator for their free-reed Fagotto. The Euphone, 8 ft., is constructed in precisely the same manner as the 16 ft. stop; and when carefully voiced and regulated is a valuable addition to the soft voices of the manual department in Organs of all classes. While the free-reed Euphone yields a refined and pleasing tone, there is much to be done to pro-

duce a perfectly satisfactory imitative Euphonium; and we commend the problem to artistic voicers who may read these pages.

Musette.—This free-reed stop, although properly of 8 ft. pitch, may be made of 4 ft. pitch for any Organ where an extremely delicate octave reed is desirable. Its tongues are made similar to those of the Cor Anglais, but somewhat narrower and thinner toward their free ends. The resonators, of the ordinary inverted conical form, should be of very small scale so as to produce a light and bright tone, imitative of that of the old Musette. The Musette of to-day is a small double-reed instrument having a bore and bell resembling those of the true Cor Anglais. We are of opinion that in Organs which contain a Cor Anglais, 8 ft., or Orchestral Oboe, 8 ft., the Musette of 4 ft. pitch should be introduced in preference to that of 8 ft. pitch. The reason for this is obvious.

Saxophone.—While the closest imitation of the tone of the orchestral Saxophones has, up to the present time, been produced by labial pipes (See Chapter on Wood Pipes: and their Modes of Construction), we are disposed to believe that a still more satisfactory imitation could be obtained from free-reed pipes. In the preceding pages we have mentioned and furnished some measurements of a beautiful free-reed Contra-Saxophone, 16 ft., made by the late Mr. Hilborne L. Roosevelt for our own Chamber Organ. We gave the stop its name simply because its tone—not strictly imitative—approached nearer to that of the Bass Saxophone, when played *piano*, than to that of any other instrument.

Of the free-reed Oboe, Clarinet, and Fagotto it is unnecessary for us to speak here: they are, in comparison with the striking-reed stops bearing the same names, absolutely worthless.

Physharmonica.—The stop to which this name is given is constructed of free reeds fitted to a small wind-chest, connected directly with a special wind-reservoir, and provided with a general resonator or sound-chamber, furnished with means for the production of a *crescendo* and *diminuendo*. The best examples of the Physharmonica to be found in European Organs have been made by Messrs. J. & P. Schiedmayer, of Stuttgart. It is due to the courtesy of this distinguished firm that we are able to give a drawing of the construction of the Physharmonica in its most approved form. Fig. CCCLX. is a Transverse Section of the complete appliance. A is the Chamber into which the compressed air from the general bellows of the Organ is conducted by a suitable wind-trunk or conveyance. This chamber is connected, through the opening D, with the bellows B, which, together with the chamber A, forms the wind-reservoir or magazine. The bellows B is acted on by the spiral spring C, which imparts the necessary attack to the wind when any reed-pallet is opened. E is a small escape-valve held against its port by a light spring. The chamber A is made of two parts, hinged and screwed together, so as to admit of ready access to the reed-work. A Longitudinal Section of a free tongue with its brass frame is shown at F, and its tuning-clip and wire are indicated at G. The tuning-wire passes practically air-tight through the side of the chamber A, to enable the tuning to be accomplished from the outside. H is the reed-groove special to the tongue F, furnished with the pallet-hole I. J is the pallet, covering the hole just mentioned, and commanded by the key action through

the agency of the rocking lever K and the pull-wire L. The pallet is held against its seat by the spring M, which is strong enough to resist the downward pressure of the compressed air on the surface of the pallet. N is the general sound-chamber, provided at its end with a pivoted or sliding adjunct for *crescendo* and *diminuendo* effects. The action of the appliance is extremely simple. When the compressed air enters the chamber A it ascends into the regulating bellows B, which, accordingly, assumes the expanded condition indicated in Fig. CCCLX. Now, when the corresponding key is depressed by the performer, the wire L is pulled up, and,

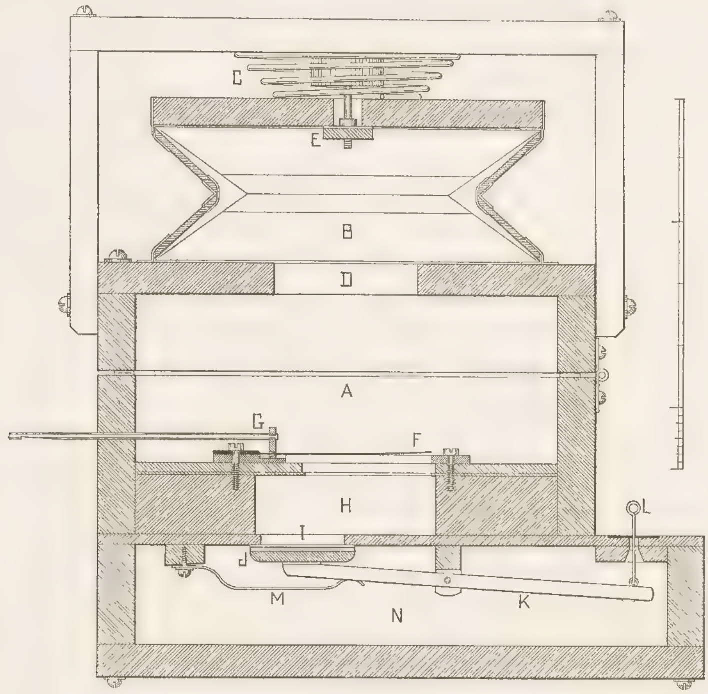


Fig. CCCLX.

through the rocking of the lever K, the pallet J is lowered from its seat, opening the hole I, and allowing the compressed air in the chamber A to act on the tongue F. The tongue is set into rapid vibration, allowing a regular succession of puffs of compressed air to enter the reed-groove H, generating sound therein, which is communicated to the air in the sound-chamber N, and from which it escapes into the surrounding air with more or less intensity according to the action of the expression-lever and its adjuncts. The free reeds of the Physharmonica are in all respects similar to those used for the ordinary free-reed stops: the only difference lies in the manner in which they are mounted.

It will be clearly understood from the above description that so far as organ stops are concerned the Physharmonica stands alone. It cannot be considered, under its peculiar treatment, to yield a tone imitative of that of any orchestral instrument, simply imparting the effect of a powerful Harmonium to any labial stops with which it may be combined. Notwithstanding the fact that it forms some agreeable combinations with the softer voices of the Organ, we gravely question its value in a properly-appointed instrument. We are not aware of a Physharmonica ever having been introduced in an English or American Organ.

THE DIAPHONE.

In Volume I., pages 399 and 400, we have spoken of the stop patented by Mr. R. Hope-Jones, and named by him Diaphone. It is, accordingly, only necessary in the present Chapter to describe, as briefly as possible, the illustrations of Diaphones, which we are able to lay before our readers through the assistance and courtesy of the Patentee. In Fig. CCCLXI. are given a Longitudinal Section and Front View of the sound-creating portion of the Diaphone in its simplest form. In this treatment we find a likeness to the action of the ordinary striking reed—a likeness which is absent in the more complicated Diaphones in which

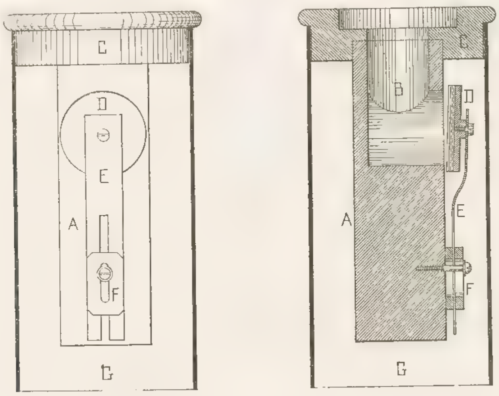


Fig. CCCLXI.

pneumatic motors are introduced. A is a quadrangular piece of hardwood, bored in the manner shown at B, and firmly attached to the block of the boot C. From this block rises the resonator, which is either inverted pyramidal in form and constructed of wood, or inverted conical in form and made of stout zinc. D is a disc-valve, faced with felt and leather, and carried on the spring E in the manner indicated. The spring E is forked in its lower part, and is held firmly between the sliding pieces shown at F. The spring is regulated by moving these pieces up or down, shortening or lengthening the effective portion connected with the disc-

valve. The action of this appliance is simple and resembles that of the ordinary striking reed. When compressed air is admitted from the wind-chest into the boot G it immediately acts on the more exposed surface of the valve D, driving it against the opening of the bore B. The valve rebounds under the action of the spring E, allowing a puff of compressed air to enter the resonator through B. The valve is again closed and again opened, and the action continues so long as the boot is supplied with compressed air. In this, as in all other forms of the DIAPHONE, the rate of vibration of the valve is controlled by the vibrating column of air within the resonator, and is not affected by an increased pressure in the pipe-wind. Writing of this simple appliance, Mr. Hope-Jones says: "I find this form of DIAPHONE very useful in producing the qualities of tone I describe under the names DIAPHONIC DIAPASON, DIAPHONIC HORN, and DIAPHONIC CLARINET." As we have not heard any one of these stops we are unable to express any opinion respecting their tonality.

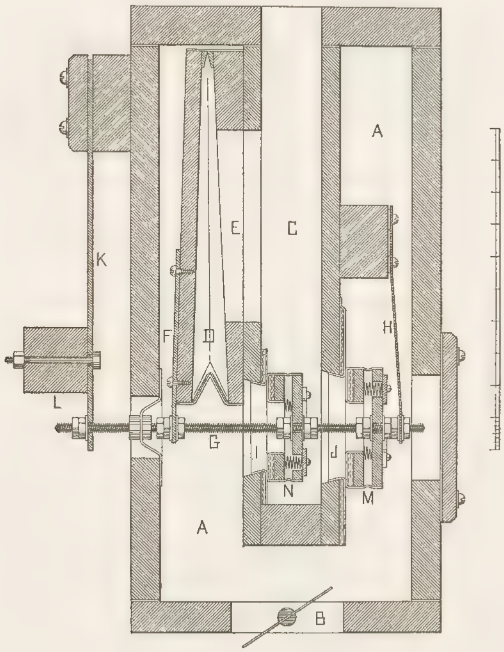


FIG. CCCLXII.

In Fig. CCCLXII. is given a Longitudinal Section of the mechanical portion of a large DIAPHONE, showing the full development of Mr. Hope-Jones' system of construction. DIAPHONES of this kind were inserted in the pedal department of the Organ in Worcester Cathedral in the year 1895, and in the same department of the Organ in McEwan Hall, Edinburgh, in 1896. In each case the DIAPHONE could be drawn of 32 ft. and 16 ft. pitch. In this form we find the three essential parts of the complete DIAPHONE; viz: (1) a valve set into motion by (2) a motor, which is controlled as to its periodic action by (3) a resonator. In the Longitudinal Section A is the boot or chamber into which the pipe-wind is admitted through the hole B. Formed between the sides of this boot is the channel C, stopped at its lower end, as indicated, and opening at its upper end into a resonator, which is planted on the top board of the boot. D is the motor in the form of a small cuneiform bellows, which is placed in communication with the channel C through the oblong opening E. The metal arm F is screwed to the

movable board of the motor, and firmly held between nuts on the tapped valve-stem G. The valve-stem is supported at its right end by the slender spring H, in the manner clearly indicated; and at its left end by the spring bar K, to which is bolted the weight L. The valve-stem passes air-tight through the leather purse P. On the valve-stem are securely fixed with double nuts two disc-valves of peculiar construction, the larger one, M, being placed outside the channel C, and the smaller one, N, inside the channel, as shown. Each valve is formed of a disc and a ring of hardwood, connected around their edges, and about ¼ inch apart, with leather. Three small spiral springs keep the leather edging stretched, while they permit the ring portion of the valve to move when the valve strikes its seat in any sudden fashion. The ring portion is faced with thick felt protected with a covering of leather. The valve-seats are also covered with felt and leather. The peculiar construction of the disc-valves M and N will be thoroughly understood from the illustration. The action of the appliance is as follows: When the compressed air or pipe-wind enters the boot A through the hole B, which is connected with some sort of wind-chest, it immediately exerts its pressure on the motor D, collapsing it sufficiently to move the valve-stem G and open the disc-valves N and M. A puff of compressed air instantly passes into the channel C through the valve-ports I and J. For the instant the air in the channel is compressed sufficiently to institute what is practically a state of equilibrium between the air inside and outside the motor D, and the spring bar K draws the motor open and closes the disc-valves. The condensation or puff of compressed air has passed upward into the controlling column of air in the resonator, breaking the equilibrium just alluded to, and allowing the pipe-wind to act on the motor, open the disc-valves, and allow another puff to enter the channel C. The equilibrium is again instituted, and the motor expands, and the valves close. This process continues with perfect regularity, the period of vibration being practically determined by the size of the column of air in the resonator. On this subject Mr. Hope-Jones remarks:

"In the Diaphone the period of the admission of the puffs of air is governed *solely* by the period of the resonator, so that the pitch accurately corresponds with that of the flue work under all circumstances, provided the bellows is arranged (as it always should be) to draw air of similar temperature to that which surrounds the pipes. Diaphones have no tuning-wires as reeds have. They are tuned in the same manner as flue [labial] pipes, and stand in tune equally well. . . .

"I stated previously that the pitch of the Diaphone depends upon, and is determined by, the period of the resonator. By giving the column of air in the resonator direct control of a motor ample in size, and by arranging the valves in correct proportion, this statement appears to be literally true, excepting when the wind-pressure is altogether too great, or when it falls so low as to fail to sustain the vibration properly. I have carefully tuned Diaphones to a pitch pipe, and have varied the pressure to as much as 800 per cent without being able to detect the slightest variation in pitch. When passed beyond these limits in either direction the Diaphone went out of tune with the pitch pipe. . . .

"It is obvious that if desired the pitch of a Diaphone may be made to be quite independent of the period of a resonator. To accomplish this all that is to be done is to exalt the office of the spring and degrade or remove that of the motor. Diaphonic valves may in this manner be got to speak with half length tubes, or without any tubes at all."

When one contemplates a piece of mechanism such as that represented in Fig. CCCLXII., and bears in mind the rapidity with which it has to act to produce a musical tone, one has good reason to question its durability and the possibility of its remaining in good working order for any reasonable length of time. On this subject Mr. Hope-Jones, writing in 1896, says:

"I am really not in a position to speak definitely on the point of durability. I can only give my opinion for what it is worth, and say that I do not think that when properly made, DIAPHONES should fail to wear well. But if the motors are found to give way after continued use, they are easily replaced."

CHAPTER XXXIX.

THE ART OF VOICING.

IN the Art of Voicing we find another subject, which, in its satisfactory and instructive treatment by the pen, presents almost insuperable difficulties. These difficulties have evidently been experienced by all who have essayed the compilation of treatises on organ construction. With two notable exceptions,* all the works on the art of organ-building in the English language, known to us, contain little if anything of value, or apparent value, on the subject. Even in the work entitled "The Organ, Its History and Construction," by Hopkins and Rimbault,—for half a century accepted as the standard work on the Organ in the language,—the subject of voicing is passed over with a few general remarks of no practical value, even when they approach correctness.

The art of voicing, like many other arts which, for their successful practice, depend upon individual acquirements and natural gifts, cannot be learned, with any certainty of good results, from written descriptions or directions, however full and explicit they may seem to be. It may safely be said that no simple tuition could, in the natural order of things, create a George Willis, a Schulze, a Thynne, or a Whiteley. A distinguished Organ Builder, in a letter addressed to us, remarks: "Unfortunately we have no Schools of Learning devoted to the Art of Organ-building, as are established in connection with the other important arts. Experience—tedious and expensive—together with individual talent and infinite patience, are the chief factors which combine to form the Voicer. It does not take a great organist to become an expert in the art of voicing; but the voicer should have knowledge of the rudimentary principles of music and the laws which

*These works are "A Practical Treatise on Organ-Building,—a very able and reliable book,—by F. E. Robertson, C. I. E.; London, 1897: and "Organ-Building for Amateurs," by Mark Wicks; London, 1887.

govern the production of musical sounds. In my experience," continues the writer, "I have found that men with good voices and capable of using them well in singing, good violinists, and men endowed with patience and great mechanical skill, make good voicers." There are very few born voicers, so to speak, although there are many who assume to be masters of the art. This is amply proved by the rarity of tonal excellence in the generality of Organs constructed in modern times. In the majority of such instruments the tonal qualities only reach the dead level of mediocrity, when they escape being positively objectionable. It is but just to add that there are very few Organs which do not contain some satisfactory stops; but the presence of these do not make up for the serious shortcomings of the rest. In a really perfect Organ every stop must be equally good tonally. George Willis, Edmund Schulze, and our lamented friend, William Thynne, have gone to their rest; but John W. Whiteley, W. E. Haskell, and a few other notable artists are still with us to show us the wonders of the organ-pipe, and to point the way to still greater achievements in the world of sound.

From the foregoing remarks it will be gathered that we have no thought of teaching the art of voicing in the remarks we now venture to lay before the reader. These remarks do not extend beyond a statement of a few facts and ideas, which have been gleaned or formed from actual observation and a limited experience; from the careful examination and study of the works of distinguished organ builders and voicers in England, Germany, and France, and, to a more limited extent, in America; and from personal intercourse with several talented artists in tone production. We can assure the student of the art of organ-building that he can learn more respecting the voicing of organ-pipes from a critical and careful examination of artistically-voiced pipes, combined with an analysis of their respective tone-colors, than he could from any writings on the subject. A long-continued comparative criticism of executed works, under the guidance of a cultivated eye and ear, is a more potent instructor than a volume of wordy particulars and directions. Of this fact there can be no question.

There are two schools of voicing: one that may be designated the normal or legitimate school, which obtained for the most part in the old great epochs of organ-building, and traces of which linger in the most artistic quarters to-day; and the other, which may very properly be called the abnormal or illegitimate school of voicing, followed much too generally in the organ-building world at the present time. In the normal school every pipe is treated in strict accord with its scale and special character; the voicer properly aiming at the direct production of the tone for which it was designed, giving it exactly the amount of wind, at the proper pressure, necessary, along with the correct and artistic manipulation of the mouth, to attain the most beautiful result, the slightest deviation on one side or another impairing the perfection of the *timbre*. In the abnormal school, the voicer simply aims at getting as much sound from every pipe as his ingenuity can devise, assisted by excessive wind-pressure; here everything is strained and necessarily coarse, tonally. The first school of voicing may be illustrated by the true English Open Diapasons as voiced by Smith, Harris, and the other old English masters, and by the Principals of the great Silbermann, of Strasbourg; while the

second school may be represented by the average harsh-voiced Montres of the modern French builders, and the countless overblown stops which crowd the average commercial Organs turned out, at so much per stop, from English and American factories to-day.

The true voicer—an artist in his calling—must, as we have implied in the preceding remarks, be a man of several natural and acquired endowments; and, in addition to the accomplishments already alluded to, must either be an expert pipe maker or have a complete knowledge of all the details which go to form perfect pipes of every description. This knowledge enables him to determine with certainty exactly the treatment best adapted to produce the finest quality of tone from the pipes entrusted to him. Beyond this, he must, in voicing any single stop, keep in mind the exact relation the tone of that stop has to bear to the tones of all the other stops in the Organ, with which it will be combined, or with which it will be contrasted. The voices of the Organ are like the pigments on the painter's pallet, which, by their skilful mixture, produce an endless variety of tone-colors—some bright and advancing, others subdued and retiring; some conveying the idea of brilliant light, others that of darkness or shade; some expressive of mirth and joy, others of mourning and sadness. If all this is granted to the voices and the tone-colors of the Organ, surely it is impossible to overrate the office or the art of the voicer. It matters not how complicated and responsive the mechanical portion of the Organ may be; how beautiful its exterior may be; and how carefully finished its pipe-work is: unless the very soul of the artistic voicer has been lavished upon its tonal forces, the whole is a failure as a true musical instrument. How seldom we observe the deference and respect paid to the voicer to which, if he is an artist, he is justly entitled. How seldom do we find him, in the average factory, occupying the highest place of honor, and provided with a retreat into which no distracting noise can enter to dull the keen perception of his ear. It is impossible for the voicer to distinguish the delicate refinements of musical *timbre* in a voicing-room into which the harsh noise of wood-working machinery and the other equally objectionable sounds of a busy factory enter. The voicing-room should in all possible cases be in a specially-appointed and detached building—held sacred to the highest art of the organ builder.

The tools required in the process of voicing are neither numerous nor elaborate. The following list includes all that are necessary under all ordinary circumstances:

A pair of proportional compasses for correctly proportioning the heights of mouths to their widths, and for setting out the positions and proportions of the slots. Required for both metal and wood pipes.

A strong pair of spring dividers for marking heights of mouths from any pipe-scale.

Two small steel hammers, with heads 3/8 inch and 1/4 inch square and thin straight tails, and handles about 1 foot long; useful for moving tuning-slides.

A pair of sharp steel nippers for cutting the ears of metal pipes.

A pair of strong scissors or shears, with blades about 2 1/2 inches long, for cutting metal pipes to required lengths, etc.

A small dovetail saw, the teeth of which have very little set, for cutting pipes, tops of slots, etc.

A couple of scratch-hooks for cutting the sides of slots in metal pipes.

A few guides of zinc or brass, of the form indicated at A in Fig. CCCLXIII., and of different sizes, for guiding the scratch-hook in slotting metal pipes.

A pair of long round-nose pliers for coiling and adjusting the strips or tongues cut from the slots of metal pipes.

Three taper-bits, having their largest diameters 1½ inches, ¾ inch, and ⅜ inch, for properly forming or enlarging the wind-holes in pipe-feet. It is convenient to have the backs of these bits marked with divisions of the inch, forming a guide in the gradation of the diameters of the wind-holes.

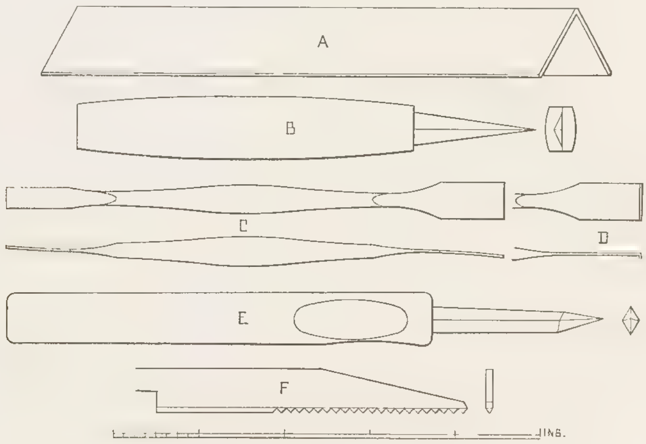


Fig. CCCLXIII.

Various straight steel wires, from $\frac{1}{16}$ inch to ¼ inch in diameter, and from 9 inches to 3 feet in length, for lifting or lowering the languids of metal pipes.

Heavy brass "knocking-up cups" for manipulating the tips of metal pipe-feet.

Several strong knife-blades, having curved backs and straight cutting edges, firmly fixed in oval wooden handles, the blades being about 2½ inches long and of varying widths to suit the different sizes of pipes.

Two thin triangular files, ground smooth and sharp, and partly imbedded in wooden handles, as indicated at B.

Lip tools of several sizes and of the forms shown at C and D. The latter form is more often used by German voicers.

A set of nicking tools or "nickers" for metal pipes, formed of diamond-shaped pieces of steel (usually ground into shape from suitable files), the free ends of which, retaining throughout the diamond form, are accurately ground to needle points. The nickers are inserted in round wooden handles, from which they pro-

ject about 2⅛ inches. The handles have hollows formed in them to enable the thumb and first and second fingers to hold the nickers exactly and always in the correct position for nicking. A representation of a large nicker is given at E.

A set of tuning-horns and cones such as are illustrated in Fig. CCCXLVIII., Page 565.

For the voicing of wood pipes the following tools and appliances are required:

An assortment of files—flat, semi-round, triangular, and knife-edged.

A set of knives of different sizes, having blades thinner than those used for cutting metal pipes, and ground and sharpened perfectly flat on both sides.

A set of nickers, comprising knife-edged files, and thin blades of steel saw-toothed in the manner indicated at F in Fig. CCCLXIII., of different sizes to suit large and small pipes.

Several square and thin flat pieces of white pine, about 8 inches long, covered on their faces with glass-paper of different numbers; required for facing and adjusting the wooden caps, etc. The flat pieces of wood vary in width from ¾ inch to ¼ inch in width. As only the extreme ends of these are used, and as the glass-paper is glued on one face only, the ends are cut away, with a long slant, to a knife edge; and this is renewed by repeated cutting as the glass-paper becomes dulled.

Beyond some chisels, small screw-drivers, and some other ordinary tools used in joinery, the above-described implements are all that are necessary in voicing.

Before commencing his manipulation, the voicer should carefully examine all the pipes forming the stop he has to treat, for it is useless to waste valuable time on any imperfectly-made pipes. He has to see that the lower and upper lips of every metal pipe are on the same plane and diametrically opposite each other, although some successful voicers claim that in pipes yielding pure organ-tone, such as those of the PRINCIPALS, the lower lip may, with advantage to both richness and promptness of speech, be set back about its own thickness from the plane of the upper lip. It is, on the other hand, absolutely undesirable to attempt the voicing of any pipe which has been made with its lower lip in advance of the plane of the upper one: the melting-pot is the only proper place for such a pipe. The languid of every pipe should be examined to see that its edge adjoining the wind-way is directly in line with the lower lip and perfectly straight.* In no case should the formation of a pipe be such as to render it necessary to depress the edge of its languid below the level of the lip before it will speak; and no satisfactory tone can be obtained under such circumstances. When the voicer is satisfied that all the pipes are properly made, and that the scale of the stop is suitable for the production of the tone required he can safely proceed with the voicing. Taking for granted the widths of all the mouths are accurate with reference to the circumferences of their respective pipes, the first proceeding is to cut the mouths to their proper heights. This can be done by first marking the upper lips by means of a

* We omitted to state, in speaking of the form of the languid in our Chapter on Metal Pipes: and Their Modes of Construction, that it is always desirable to finish the voicing edge with a very small counter-bevel, so that the nicking is executed on an edge forming an angle of 90°, instead of one having an angle of 45° or thereabout.

proportional compass, which, once adjusted to give the height in some definite proportion to the width of mouth, will secure perfect uniformity throughout the stop. If preferred, the heights may be obtained directly from the pipe-scale on which all measurements are set out. The lips are then cut with the knife provided for the purpose accurately to the lines scratched along them by the compass. Any paring required to thin or sharpen the lips may now be executed with a sharp knife, provided the voicer is perfectly certain of the final results. At this stage the pipes that are to be voiced first, preferably those of the middle octave, must have the wind-holes in their feet properly adjusted with reference to the pressure of the pipe-wind, and the necessary supply of the same for the production of the desired quality and strength of tone. The pipe-feet are first contracted at their tips by means of the knocking-up cup, and their wind-holes are clearly cut to size with a taper-bit. Their adjustment to the requisite size is commonly done by the unaided eye, cultivated by long experience; while in better-class work taper-bits marked on their backs with divided inches are used to give some sort of a guide to the voicer. When absolute accuracy of gradation is aimed at in the wind-holes of a series of pipes, it is necessary to use a gauge. This gauge is properly in the form of a long and comparatively slender conical rod of polished steel, on which is marked a scale indicating diameters to hundredths of an inch. By inserting this gauge in the wind-hole of a pipe-foot its diameter can be accurately ascertained; and each successive wind-hole can be correctly gradationed in size from any starting point. These pipes may now be placed on the voicing-machine and tested with the view of arriving at some idea as to their future behavior, and to ascertain if the adjustment of their languids to their lips is correct. If any languid is too low, it has to be raised by passing a wire up through the wind-hole in the foot of the pipe, and pressing or gently tapping it against the under side of the languid close to its edge. If, on the other hand, the languid is too high, it can be lowered by means of a long wire inserted in the body of the pipe and pressed downward on the upper surface of the languid: or, when large, it can be pressed down with the flat of a chisel inserted through the mouth. When the correct position of the languids has been determined the pipes are ready to be finished by the process of nicking.

At this point it is desirable that the inexperienced reader should refer to what has been said in Chapter XII., pages 376-396, respecting the manner in which sound is generated in labial pipes; for a clear insight into the operations of the wind at the mouth of a pipe will greatly aid him in understanding the remarks offered on the present subject of voicing. The reader may with advantage scan our Chapter on the Anemometer, so as to understand, should he not be conversant with the subject, matters relating to wind-pressures.

Mr. F. E. Robertson, who, in addition to his many other accomplishments, is an expert voicer, says in his "Practical Treatise on Organ-Building": "It may be noted here [page 245] that the notching [nicking], which is properly supposed to be the *voicing*, forms a very small part of the operation, and is by no means indispensable, as carefully-made large metal pipes will speak perfectly well without it, and the writer never uses it in wood pipes, except those with flat blocks." It has been asserted, and apparently on reliable authority, that in the pipe-work of

some old German Organs no nicking is to be found. From our personal experience, based on some practice, and much more on the study of the works of the leading schools of voicing, we consider that, while it is practicable to test an unnicked pipe in the manner and for the initial purpose we have alluded to above, it is impossible to obtain a prompt, brilliant, and generally satisfactory tone from a metal labial pipe without resort, in some form or to some extent, to the process of nicking. It is in this process that the judgment and manipulative skill of the artistic voicer is pre-eminently demonstrated. All the conditions that can attend a metal pipe—its formation and material, its length and relative scale, the quality and strength of tone it is required to produce, the pressure of the pipe-wind, and its supply and consumption—affect the process and style of nicking. Such being the case, it is evident that only particulars respecting this delicate process, of the most general application, can be given in these pages. In certain classes of wood pipes nicking is altogether omitted, while in others nicking of the most pronounced character is absolutely necessary for tonal development. This obvious fact, known to every voicer, is fully set forth in our Chapter on Wood Pipes.

By the use of the nicker, of the form indicated at E, in Fig. CCCLXIII., different tonal effects can be produced. The nicks may be placed close together or comparatively wide apart; and they may be cut shallow or deep by applying the nicker with different degrees of pressure: but in all cases the form of the nicker will impart the same relative proportions of width to depth to the nicks. Such being the case, nicking-tools having their cutting edges set at different acute angles are used for the voicing of the several classes of pipes.

In the pipes yielding pure organ-tone, such as those of the true English OPEN DIAPASON, 8 FT., the nicking is knife-like; namely, deeper than wide. In the CC pipe they number about 11 to the inch. The number is gradually increased and the nicks become smaller as the pipes decrease in size. At middle c^1 about 19 nicks are commonly cut. In the German PRINCIPAL, 8 FT., while about the same number of nicks, as above stated, are adopted, they are wider in proportion to their depth than the nicks of the English pipes. In the pipes of this class which have leathered upper lips, very few nicks, cut with a triangular tool, are introduced; for instance in the CC pipe 3 bold nicks to the inch are considered sufficient, while at middle c^1 8 nicks to the inch are found to be satisfactory.

A skilful and experienced voicer, in a communication on the subject of voicing, makes the following pertinent remarks: "Careful nicking is a most important factor, and has great influence on speech and tone. It is not possible to form any set rules, as pipes vary so much. Take pipes made to the same details by different men, and the results are different according to the ability and character of the makers. Consequently what is perfectly satisfactory, in the matter of nicking, for one set of pipes, may not do for another set: one may require a certain number of nicks, while another will perhaps sound better with less. All this can only be determined by absolute test."

The class of pipes which call for a somewhat bold description of nicking, combined with special proportions of mouth, is that which embraces pipes yielding unimitative flute-tone, such as those forming the BOURDONS, LIEBLICHGEDECKTS,

Rohrflöte, Spitzflöte, Bassflöte, and certain forms of Harmonic Flutes. The height of mouth in proportion to its width, the form of the upper lip,—straight and parallel to the lower lip, or arched,—and the supply and pressure of the wind, dictate the style of nicking best calculated to produce the normal and most satisfactory tone of the pipe.

The pipes which, under ordinary conditions and of ordinary scales, call for the closest and most delicate style of nicking are those yielding imitative string-tone. The following remarks from the communication already alluded to are interesting and instructive: "The mouths of string-toned pipes must be clean cut, having parallel lips and ears in every case. The mouths, small in the bass pipes, should be made gradually wider as they ascend the scale. Wide nicks (in proportion to depth) placed about the width of the nicks apart induce fulness. If the nicking is placed too closely, or made deeper than wide, it will incline the speech to unsteadiness. The same tendency obtains if the mouths are too wide or too high. The less the wind-pressure, the finer the nicking must be. In some cases," continues this authority, "I have nicked the lips only, and in others the languids only. My general method is to nick the languid sufficiently to produce the dry, acrid quality of first speech; then to nick the lip in proportion to the amount of bloom that I desire for the particular stop in hand. It is easy to obtain a slow, dry, acrid tone: the difficulty is to get rid of it, and maintain the quality of freshness and bloom combined with promptness of speech. These remarks apply to all delicate-toned stops, such as the Echo Salicional and Viola d'Amore.

"In a general way, a string-toned pipe is first made too quick of speech, and then curbed back to the ground tone and proper articulation by placing the harmonic-bridge in correct position. There are several different results obtained by the application of the harmonic-bridge, or the *frein harmonique*, especially when used on string-toned pipes. It may be employed: (1) To steady the tone, without having any reference to quality of tone or quickness of speech. (2) To increase the sequence of the over-tones, by mechanically increasing the force of the current of air across the mouth. (3) Most valuable of all, to fix or lock the tone in such a way as to make it stand as reliably as that of an Open Diapason. To secure this I carry the harmonic-bridges up to the c^3 pipe, using tubes of aluminium. The shape of the bridges has not much influence on the tone, while their position is everything. This latter has to be determined by experiment, treating each pipe on its own merits. It is a curious fact that by a special application of the harmonic-bridge it is possible to make an open pipe, in sounding its unison or ground tone, sound also its octave below."

Another talented voicer remarks: "All string-toned pipes are now fitted with the harmonic-bridge, which is a roll of metal or wood across the mouth. The nicking of string-toned pipes must be fine and close, but deep enough to prevent spitting. Coarse nicking will never produce a string-tone, while, on the other hand, too fine nicking in pure organ-toned and flute-toned pipes will fail to produce a round or mellow tone. Before applying the harmonic-bridge, the pipe under treatment must speak its octave [first upper partial tone] promptly and firmly; and then the bridge has to be so adjusted [between the ears of the mouth] as to insure

prompt speech of the ground tone of the pipe in its desired quality and strength. The cutting-up of the mouths of string-toned pipes is determined by the strength of tone required: it properly varies from one-fourth to one-third the width of the mouth. The tuning-slot in each string-toned pipe should begin at one diameter of the pipe from its top, and be of a width equal to the height of the mouth of the pipe. When the pipe is in tune the length of the opening of the slot should not as a rule exceed the diameter of the pipe; but much greater lengths have been adopted for the production of special qualities of tone.

"The mouths of flute-toned pipes are cut up either straight or arched. It is impossible to give a definite rule; but it may be claimed that for certain pipes, such as those forming the FLÛTE HARMONIQUE, ROHRFLÖTE, DOPPELFLÖTE, GEDECKTS, and manual and pedal BOURDONS, the arched mouths are more satisfactory when a mellow tone is desired." Speaking of the desirable widths of mouths, the same authority remarks: "Pipes of the PRINCIPAL or OPEN DIAPASON class should have mouths of a width equal to one-fourth of their circumference; of the GAMBA class, one-fourth or two-ninths of their circumference; of a soft intonation, one-fifth of their circumference; and the last-given width is most suitable for flute-toned metal pipes, and those generally which are tapered in form, being conducive to the production of a satisfactory intonation."

We may conclude our brief remarks on the treatment of metal labial pipes by touching on the imperfections they commonly display during the process of voicing, and the remedies generally found efficient.

When a pipe is too loud, it is due to an excess of wind. This can be remedied by reducing the wind-hole in its foot, and by slightly pressing the lower lip toward the languid, thereby reducing the wind-way of the mouth. This latter must be done cautiously.

When a pipe is too soft, the exact reverse of the preceding remedies will remove the fault. Should the softness be very slight, in all probability the enlargement of the wind-hole will prove sufficient. When the quality of tone is satisfactory, the less that is done to the lips the better.

When a pipe overblows or speaks its octave, it is due either to an excess of wind, or to the front edge of the languid being below the line of the lower lip. When the former is the case, the fault can be remedied by reducing the wind-hole in the foot. When the languid is too low, it must be raised very carefully by means of a wire passed up the foot.

When a pipe is too slow of speech, or its note comes on with a disagreeable drag, the fault is due to the wind stream being thrown too far in front of the upper lip. To remedy this, it is necessary to lower the languid very slightly, either by means of a long wire passed down the body of the pipe, or (in the case of large pipes) by pressing on its upper surface with the flat of a chisel. Care must be taken to keep the edge of the languid true to that of the lower lip.

When a pipe spits or chiffs before speaking its proper tone, the fault is commonly caused by the nicking not being deep enough, or at other times by the wind-way being too open. This fault is, accordingly, cured by cutting the nicks deeper, or by slightly reducing the distance of the lower lip from the languid.

When the tone of a pipe is unsteady in any manner, the fault may be due to several causes, the chief of which belong to the formation or nature of the pipe itself. The pipe may be constructed of too thin metal, and, accordingly, not be able to withstand the tremor of the column of air within it. The body of the pipe may not be perfectly round throughout its length. In the former case the only radical cure is a new pipe of proper weight, while in the latter case the fault may be removed by placing the pipe on a mandrel of proper size and beating it truly cylindrical. An unsteady tone is sometimes caused by the wind stream not ascending with sufficient strength across the mouth: this can be cured, if the mouth has not been cut up too high, by increasing the wind supply. Again, it may be caused by a wrong direction given to the wind stream across the mouth: when such is the case, a slight raising of the languid will effect an instant cure. If the mouth has been cut up too high, the body of the pipe must be detached from the foot, cut shorter at the mouth, and re-soldered. A better method is to voice an entirely new pipe. Unsteadiness is sometimes the result of bad planting and consequent overcrowding in confined positions: this is a serious matter, for no simple manipulation of the pipe can effect a remedy.

When a pipe, under proper treatment, refuses to speak, or, at best, yields a sickly tone, there is something imperfect in the pipe itself. The fault may be caused by an open seam or a hole somewhere in the metal of an open pipe; while in a stopped pipe, in addition to the above defects, it may be caused by a badly-fitting stopper or cap. The remedies are obvious.

Windiness is a very objectionable accompaniment to the tone of a pipe, but one that, with proper care in the construction of the pipe-foot and the channel or duct which supplies it with wind, should rarely if ever occur. It is true that a pipe which is perfectly free from any trace of windiness while on the voicing-machine may develop the imperfection when planted in the Organ, but this is almost invariably due to unscientific planting, born of inexperience or carelessness.

In the case of both speaking and dumb displayed pipes, great care must be taken to so mount them that no vibration nor rattling is possible. The pipes must rest firmly in their sockets, and be held tightly in their supporting rails—preferably felted where the pipes touch.

The voicing of wood pipes differs considerably from that of metal pipes, for in them there are no flexible lips to be moved inward or outward, and no languids that can be raised and lowered by the pressure of a wire at will. As the subject of wood pipes is fully treated in Chapter XXXIV., and illustrated by the series of fifty-six accurately-rendered drawings, it is only necessary to give a few particulars here, confined to the ordinary methods of voicing. If a wood pipe has been carefully made of properly-seasoned wood, and accurately dimensioned in all its parts according to a consistent and correctly-graduated scale, its voicing should, in experienced hands, be a matter of ease and certainty. The manufacture of wood pipes has only in very rare instances been carried to any great degree of perfection by English and American organ builders: and it is rare indeed to see wood pipes constructed with anything approaching the accuracy which obtains in carefully-made metal pipes. It is difficult to understand how such a master as the great

Willis almost totally ignored wood pipes, as proved by his largest Organ in Royal Albert Hall, Kensington, London, while the renowned artist in tone-production, Edmund Schulze, proved by his fine works in England the great value and beauty of wood pipes both in complete stops and as parts of metal stops.

In considering the voicing of wood pipes, the following facts or conditions should be borne in mind: (1) That while the mouths of metal labial pipes of all classes are formed on practically the same lines, those of wood pipes present several different formations. The three leading formations are shown in Fig. CCLIX. (page 440), while others are shown in the illustrations given in Chapter XXXIV. (2) That the upper surface and the outer edge of the block of a wood pipe fulfil the same office as the languid in a metal pipe. (3) That the position or level of the block cannot be altered in the process of voicing, as in the case of a metal languid. (4) That the lower lip of a wood pipe is furnished by the inner upper edge of the cap. (5) That the wind-way of a wood pipe having an inverted mouth is invariably formed by cutting or filing away portion of the inner upper edge of the cap, as indicated at C in Fig. CCLIX. and in the right-hand Longitudinal Section in Fig. CCLX. (6) That in the case of a pipe having the ordinary direct mouth, the wind-way may be formed in the cap in the manner above mentioned, the cap being depressed slightly below the upper edge of the block, as indicated at A in Fig. CCLIX.; or it may be formed by leaving the inner surface of the cap flat, and by setting back, by careful cutting or filing, the upper edge of the block, which latter is sloped toward the throat so as to leave an acute-angled edge. In this case the upper edge of the cap is placed level with the upper surface of the block, all as indicated at B in Fig. CCLIX. and in the left-hand Longitudinal Section in Fig. CCLX. (7) That while the upper lip of a wood pipe can be cut up straight or arched, and cut sharp or left thick and rounded, it cannot be moved inward or outward like the upper lip of a metal pipe. In wood pipes this rigidity is a decided advantage. (8) That should a wood pipe be imperfectly formed and fail to yield its proper tone, there is no alternative but to procure a new pipe.

Absolutely no rules of anything approaching universal application can be formulated for the voicing of wood pipes. The variety of methods which have been followed by artists in this line is far greater than that presented by the entire school of metal-pipe voicing. This is not to be wondered at, seeing that the forms and proportions of wood pipes admit of practically limitless changes. The chief aim of the voicer is to form and properly direct a wind stream of the necessary strength and elasticity across the mouth of the pipe under treatment. This is accomplished by admitting sufficient wind at the pipe-foot, giving the wind-way the necessary opening, and so adjusting the cap to the block that the wind stream will be forced to take its proper direction across the mouth. The wind-way, whether it is formed in the cap or in the block, is usually cut straight and equal throughout its length; it must be finished smooth by the application of the finest glass-paper (glued to a flat piece of wood, as previously described); and, for really fine work, it should be black-leaded and burnished. To protect wind-ways which are extremely fine and do not admit of the slightest alteration when once accurately formed to produce the quality and strength of tone required, they should be pro-

tected from the swelling action of moist air—to which they are frequently subjected—by being well saturated with a solution of shellac and pure alcohol (95%), carefully smoothed, and finally black-leaded, or burnished with a piece of hardwood and beeswax. Such extreme care in the formation of the wind-ways of wood pipes is very seldom indulged in in this age of competitive and cheap organ-building; but the true artist neglects nothing that is conducive to perfection and stability of tone. Certain flute-toned pipes have wind-ways of special forms, as that indicated in Fig. CCLXXVIII., page 446.

On the subject of nicking it is extremely difficult to say anything of positive value; its application to wood pipes seems, so far as our own observation goes, to be extremely erratic, hardly two voicers appearing to agree in their use and disuse of it. As a general rule, however, it is seldom applied to the wind-ways formed in acute-angled blocks having flat and flush caps, as indicated in the left-hand Longitudinal Section in Fig. CCLX. (page 441). In pipes yielding string-tone, in which the blocks are cut to a sharp edge, and the harmonic-bridge or *frein harmonique* is used, nicking is seldom adopted. All the pipes of this class in our possession have no nicks on either block or cap. When the cap is hollowed and the edge of the block is sharp, and the wind-way is formed in the cap only, or partly in both the cap and block, nicking may with advantage be sparingly applied to the cap. A good example of this treatment is given in Fig. CCLXXXVI. (page 475). Nicking is seldom applied to the lower lip of an inverted mouth; but a good example of its use is furnished by the pipe illustrated in Fig. CCXCI. (page 484). For the production of smooth flute-tone in pipes having ordinary direct mouths fine and nicely-executed nicking is required. Further particulars on this subject will be found in the descriptions of wood pipes given in Chapter XXXIV.

The nicks are formed in wood pipes by means of the notched nicking-tool represented at F in Fig. CCCLXIII., which is made of several sizes to suit different pipes; or the nicks are formed by knife-shaped, clean-cutting files. Absolute uniformity both as to size and distance apart must obtain in the nicking of each pipe: any irregularity is apt to impair the action of the wind stream, injure the tone or make it unsteady. Some voicers, in nicking the flat-faced blocks of the ordinary old English form, cut the nicks in a diagonal direction; and when the corresponding caps are also nicked, they cut the nicks diagonally in the reverse direction.* It is difficult to understand what is gained by this treatment, which is, of course, impossible in metal pipes.

Respecting the voicing of reed pipes, we need not add to what we have said in Chapter XXXVIII. As Mr. F. E. Robertson remarks in his able Treatise: "If it is difficult to put in words the voicing of flue pipes, it is ten times more so to describe that of reeds. Unwearied patience and good powers of observation and reasoning will enable the thing to be done somehow; but it requires a natural gift, or the experience of a lifetime, to produce a really fine rich tone from reeds."

*An illustration of this peculiar style of nicking is given in Mr. Mark Wicks' "Organ-Building for Amateurs," page 217. This little work contains some useful hints on nicking.

CHAPTER XL.

PITCH, TUNING, AND REGULATING.

IT is not our intention to discuss the subject of Musical Pitch at any length, although, thanks to the kindness and valuable assistance of the late Mr. A. J. Hipkins, F. S. A., much important and instructive matter lies before us, which he freely placed at our disposal. About the year 1899 the question of musical pitch was seriously introduced into public discussion by the leading pianoforte manufacturers of the world, who at that time were not in strict agreement on what an international standard pitch should be. This is clearly indicated by the following Table, which gives the pitches adopted by ten great musical-instrument makers according to the above authority.

ORCHESTRAL PITCH IN THE YEAR 1899.

PLACE.	AUTHORITY.	PITCH.	PLACE.	AUTHORITY.	PITCH.
Leipzig . .	Blüthner . .	a^1 435	Petersburg .	Becker . . .	a^1 439·4
Berlin . .	Bechstein . .	" 438	Meiningen .	Mühlfeld . .	" 439·5
New York .	Steinway . .	" 438·6	Stuttgart .	Schiedmayer .	" 440
Boston . .	Chickering .	" 438·8	Vienna . .	Bösendorfer .	" 440
London . .	Broadwood .	" 439	Paris . . .	Érard . . .	" 442 4

Mean of the above vibration-numbers at the temperature of 68° Fahrenheit or 20° Centigrade gives a^1 439 vibrations.

The following interesting remarks from the pen of the late Mr. Hipkins contain all that need be given here on the semi-historical side of the subject under consideration :

"France introduced, by law, the Diapason Normal in the year 1859, and has been gradually followed by Belgium, Italy, Germany, Austria, Russia, the United States of America, and Great Britain. The difference of the vibration-number as compared with the old high

pitch is not so very much; if it were a semitone, it might be easier rectified,—at least in Concert-room Organs;—it may be stated at 3/5 or at most 2/3 of an equal semitone. In its measurement temperature has as yet met with insufficient consideration. It is hardly alluded to in the "Sensations of Tone" by Helmholtz; it meets with a bare mention only, although somewhat extended in the foot-notes of the English translator, the late Dr. A. J. Ellis, who refers (page 90, second edition) to the experimental work in that direction by Mr. Blaikley.

"It is well known that the French Diapason Normal is stated as $a^1 = 870$ vibrations a second at the temperature of 15° Centigrade. As we reckon by complete vibrations, we take this number at one-half,—435,—with the temperature of 59° Fahrenheit. Although this is a very good temperature for open-air music, as military bands, etc., it is not high enough for operas and concerts taking place in confined spaces with audiences and artificial lighting. The opera and concert orchestras have, therefore, everywhere to find their own pitch evolved from the French standard to suit an average increase of temperature. If the French Commission had decided on the temperature of 20° Centigrade (68° Fahrenheit), the necessity for an empiric proceeding would have been avoided. The Commission might very well have adopted Scheibler's suggestion, made in 1834 at Stuttgart, of $a^1 = 440$. It is known that he worked at a temperature of about 70° Fahrenheit. To him we owe the only facile tonometer, for which his pitch was really $a^1 = 439{\cdot}5$. It is as well to go back to the protocols of the Congress at Vienna in 1885, which led to the adoption of the French pitch in Austro-Hungary. After a unanimous acceptance of the Diapason Normal at 15° Centigrade, it was proposed that, in order to keep the wind instruments in performance to the initial standard vibration-number $a^1 = 435$, the brass and wood wind instruments, and also the Organ, should be made for 24° Centigrade (75·2° Fahrenheit):—thus introducing a second standard to be used concurrently with the first, the necessity attributable to the vibration-number being increased automatically by the heating and rarefaction of the air increasing its velocity, and with the orchestral wind instruments by the breath and handling of the players. Mr. Blaikley has shown that the velocity of air in pipes is always less than in free air, possibly through the friction of the walls, but in the organ labial pipes it comes so near to free air that the Organ may be almost regarded as a thermometer. So high a temperature as 24° Centigrade was not left unchallenged; a wiser determination was urged of 20°, which in practice would have proved right. However the great differences likely to arise in average temperatures due to climatic conditions, and to warming and lighting apparatus, as, for instance, gas or electricity, prevented a decision from being arrived at; so that Vienna is now [1899], as London was pending the decision of the Philharmonic Society, using a convenient empiric pitch of about $a^1 = 440$ for concert performances. Ingenious as the Viennese plan in 1885 would have been, it is wiser to have one standard with one note, a^1, for its expression, and one mean temperature. For brass-instrument makers a $b\flat^1$ fork may be used, and to suit the old custom of organ builders and pianoforte makers, a c^1 fork; but in preparing them equal temperament should be rigidly observed.

"After certain distinct efforts had been made in England to establish the adoption of the French pitch, the decisive step was taken when, in July 1896, the Philharmonic Society—the most eminent musical institution in Great Britain—elected to adopt the French Diapason Normal, and in the following November decided to have a standard tuning-fork for their concerts. Having consulted me, the Directors accepted my suggestion for that pitch, that it should be $a^1 = 439$ at the temperature of 68° Fahrenheit. Forks made for the Society by Messrs. Valentine and Carr, of Sheffield, were verified by me with the aid of the Scheibler tonometer in the Science Department, South Kensington. In the minute of the Society the $b\flat^1$ is stated to have the vibration-number 465, and the c^2 the vibration-number 522; this latter happens to be a just minor third above $a^1 = 435$, an accidental, although useful, coincidence.

"The vibration-number 439 is really the French standard raised to an average perform-

ing temperature, theoretically by my coefficient of a thousandth part of a complete vibration a second for one degree Fahrenheit, so that for 435 the rise for the next degree is 0.435. In a variety of ways I have sought an average concert temperature which I have finally taken at 68° Fahrenheit, at which strings, wind, Organ, and Piano should be in tune. According to my coefficient $a^1 = 435$ at 59° should be $a^1 = 438 \cdot 93$ at 68°. The round number 439 is more convenient. It would be a concession of great importance, which the musical world could not be too grateful for, if the French Diapason Normal were revised for the higher temperature 20° Centigrade, and legalized for France at $a^1 = 439$.

"The objections to the $a^1 = 439$ that have been urged are that wind-instrument makers may take it as a starting point for a lower temperature than 68°, but not if they are conscientious. We can legislate for this no more than we can for the tendency to exceed the present high pitch, as is shown by our military bands and the majority of the brass bands in Great Britain, in spite of Kneller Hall, which is bound to maintain the old Philharmonic pitch until the War Office releases the army from it and provides or sanctions French-pitch bands. Organ builders who can work with accurate forks and a thermometer will have no difficulty with the French pitch."

On the subject of musical pitch generally, and for the present purpose, little need be added to what is said above. Mr. Hipkins properly points out the necessity of recognizing the factor of temperature, which in the use of the tuning-fork is too often overlooked. It must be steadily borne in mind by the tuner that the tuning-fork marked $a^1 = 435$ (correct French Diapason Normal) has that vibration-number only at the temperature of 15° Centigrade or 59° Fahrenheit—a temperature much too low to be generally accepted for tuning purposes. In concert-rooms, churches, and even in private music-rooms artificially heated and lighted, or in which many persons congregate, a much higher temperature invariably obtains during musical performances or religious services; and this fact must not be ignored in determining the proper vibration-number to which the Organ should be pitched and tuned. The following Table, which gives the proper vibration-numbers, consistent with the French Diapason Normal, at temperatures ranging from 59° to 68° Fahrenheit, will be useful to the organ voicer and tuner:

VIBRATION-NUMBERS ACCORDING TO DIAPASON NORMAL AT DIFFERENT TEMPERATURES.

TEMPERATURE.	VIBRATIONS.	TEMPERATURE.	VIBRATIONS.
59° Fahrenheit. . . .	$a^1 = 435 \cdot 0$	64° Fahrenheit. . . .	$a^1 = 437 \cdot 2$
60° " . . .	" 435·4	65° " . . .	" 437·6
61° " . . .	" 435·9	66° " . . .	" 438·0
62° " . . .	" 436·3	67° " . . .	" 438·5
63° " . . .	" 436·7	68° " . . .	" 439·0

According to equal temperament, at the temperature of 60° Fahrenheit, the exact vibration-number of $a^1 = 435 \cdot 45$ gives the corresponding c^2 above the vibration-number 517·84, while at the temperature of 68° the vibration-number of c^2 is 522·00. In the above Table one place of decimals is adopted because it is quite unnecessary for practical purposes to carry the decimals to more places.

The adoption of a standard pitch for all Organs is a matter of importance, whether they are to be used, as in churches, for the accompaniment of the voice, or, as in the concert-room or private music-room, in concerted music with other instruments. There can now be no question that the French Diapason Normal is the only desirable standard pitch for universal adoption.

TUNING.

Before entering directly on the subject of Tuning, a few words may properly be said on that of Temperament. Two systems have been followed in tuning the Organ, whereby the sounds of the different intervals comprised within the octave have been tempered or modified in different ways from just intonation—a proceeding absolutely necessary in such an instrument as the Organ, in which there are only twelve fixed sounds in the septave or thirteen in the octave. The earlier system, which continued in almost universal use up to a very recent period, is that known as mean-tone* temperament or, more commonly, unequal temperament. This system, barbarous as it must appear to us at the present day, was encouraged and strongly advocated by the old musicians, because it secured perfectness in the thirds, at the sacrifice, however, of all the fifths, which were necessarily left very flat, some so much so as to produce sounds compared to the "howlings of wolves." This system obtained without question in England up to the year 1854, all the Organs in the Great Exhibition of 1851 being tuned to unequal temperament. It is right to remark, however, that under the influence of German teaching some isolated instances of a departure from this system existed in England anterior to the date above given. The practical abandonment of unequal temperament seems to have taken place in France, so far as the Organ is concerned, about the year 1835, when the great Paris builder A. Cavaillé-Coll ceased to use it for his important instruments. In the early part of the eighteenth century the unequal temperament was condemned in Germany, as unsuitable for instruments of fixed intonation, by both Johann Sebastian Bach and his talented son Carl Philipp Emanuel; but even their well-founded opinion failed to influence the great organ builder Gottfried Silbermann (1683–1753), who to the last remained satisfied with the crudities of the old system.

The system advocated by the Bachs, and to prove the incontestible advantages of which Johann Sebastian Bach wrote his famous "Wohltemperirte Klavier"—a collection of Preludes and Fugues in all keys—is that known as equal temperament. In this approved and now universally-recognized system the octave is divided into twelve equal or similar intervals. This tempering is one of degree, which requires the augmentation of certain intervals and the diminution of others, so as to render the performance of music written in all the keys equally agreeable—an impossible thing on any instrument tuned in unequal temperament. While in

* "Otherwise Mesotonic; so called because in this tuning the Tone is a *mean* between the Major and the Minor Tones of Just Intonation; or half a Major Third." "A Dictionary of Music and Musicians," edited by Sir George Grove:—Article "Temperament."

unequal temperament certain keys are very smooth and satisfactory, others, into which the so-called "wolf" is thrown, are most objectionable to the musical ear, so much so, indeed, that they can never be used.

In equal temperament all the intervals, with the single exception of the octave, which must invariably be perfect, are tempered more or less imperfect according to their position in the scale. To tune in equal temperament is, accordingly, and more correctly speaking, to *mistune.* In this system the mistuning consists in systematically rendering certain intervals flatter than perfect and other intervals consistently sharper than perfect, as follows :

Untempered Intervals—Perfect.

All Octaves throughout the scale.

Tempered Intervals—Flattened.	*Tempered Intervals—Sharpened.*
Fifths, slightly flattened.	Fourths, slightly sharpened.
Minor Thirds, moderately flattened.	Major Thirds, considerably sharpened.
Minor Sixths, moderately flattened.	Major Sixths, considerably sharpened.

In tuning the Organ, the intervals of the octave, fifth, and fourth are alone made use of. Tuning can be executed in a satisfactory manner by three methods: by using the octaves, fifths, and fourths; by using the octaves and fifths only; or by using the octaves and fourths only. The first method, which combines the two others, is, we consider, the best under ordinary conditions. Although the thirds do not directly enter into any of the above methods of tuning, they are useful as tests or proofs of accuracy. The major thirds resulting from the tuning in equal temperament are considerably sharper than perfect. This arises from the fact that three successive perfectly consonant major thirds, in the ratio 5 : 4, will fall short of completing the octave which comprises them by the small quantity known as a *diesis*—expressed by the ratio 128 to 125. To temper the major thirds, so that they shall span the perfect octave, it is necessary that each shall be sharpened to the extent of one-third of the *diesis.*

Before proceeding to the subject of practical tuning, it is desirable to dwell somewhat on that directly relating to the theory of equal temperament. In doing so we shall, without any desire to plagiarize, have to go over ground already well covered by other and able writers on the theory. By the term temperament, as applied to the tuning of a musical instrument having a *fixed succession of sounds,* such as the Organ and Pianoforte, is denoted a small deviation from the perfect purity of the intervals, so that all intervals assume relations which render them equally useful in both harmony and melody. The tempering is accomplished by subtracting from or adding to the original purity of the several intervals, within the octave, a minute quantity, in order that *all the sounds* so tempered may, throughout the scale or compass, be so related that *each one* will form equally serviceable intervals with *all the other sounds ;* and that *each one* comprised in any octave will serve as the proper root or tonic of a major or a minor scale,

every one of which will comprise intervals in exactly similar relationship. By this simple arrangement every one of the twenty-four major and minor scales becomes equally valuable in musical composition, and equally agreeable to the ear.

A stretched string—properly that of the Monochord—is commonly employed to demonstrate the ratios which obtain in the several intervals comprised in the octave, by dividing the string into vibrating divisions or segments. Understanding that the entire length of the string represents the tonic or root, the following Table shows the ratios of the intervals:

RATIOS OF THE INTERVALS.

	Length of String.		Segments of String.		Length of String.		Segments of String.
The Octave is in the ratio of	2	to	1	The Major Sixth is in the ratio of	5	to	3
The Fifth " " "	3	to	2	The Minor Sixth " " "	8	to	5
The Fourth " " "	4	to	3	The Major Second " " "	9	to	8
The Major Third " " "	5	to	4	The Major Seventh " " "	15	to	8
The Minor Third " " "	6	to	5	The Major Semitone " " "	16	to	15

By the above Table it is shown that if the entire length of a string yields a tonic note, the half length yields the octave; two-thirds of its length yields the fifth above; three-fourths of its length yields the fourth above; four-fifths of its length yields the major third above; five-sixths of its length yields the minor third above; and so on until fifteen-sixteenths of the entire length of the string yields the major semitone. Now, if we suppose the entire length of the string to yield the note C (4 ft.), the lengths of the vibrating segments required to yield the succeeding diatonic notes of the major scale are as follows:

C	D	E	F	G	A	B	c^1
1	$\frac{8}{9}$	$\frac{4}{5}$	$\frac{3}{4}$	$\frac{2}{3}$	$\frac{3}{5}$	$\frac{8}{15}$	$\frac{1}{2}$

To exemplify the use of the fractions above given, resort has been made to whole numbers; and the length of the string required to yield the note C is supposed to be 360 inches. Accordingly, the lengths of the string required to yield the seven succeeding notes are as given below:

C	D	E	F	G	A	B	c^1
360	320	288	270	240	216	192	180

An anonymous writer, who appears to have been the first to apply the above series of numbers,* remarks: "If we now compare, one with another, the intervals formed by the notes of the above scale by means of their corresponding numbers, we shall find that they all preserve their original purity, except the minor

* In "The Tuner's Guide." London. No author's name nor date of publication given.

third D—F, which presents itself in the ratio of 320 to 270, that is, of 32 to 27, instead of 6 to 5; and the fifth D—A, which presents itself in the ratio of 320 to 216, or 40 to 27, instead of 3 to 2, the natural ratio. If we continue the scale an octave higher, we shall find the sixth F—d^1, and the fourth A—d^1 will labor under the same imperfection. A comparison of these ratios of the minor third and perfect fifth with the perfect ratios of those intervals will show that both are too small by the *syntonic comma*, a minute interval represented by the ratio of 81 to 80. Hence, if, in a melody in C major, we introduce the A as a perfect sixth to C, in the ratio of 5 to 3, and place under it as a bass the note D [DD], then will the fifth D—A [twelfth DD—A] be too flat by the *syntonic comma*. As experience shows us that, in so perfect a consonance as the fifth, the ear cannot endure the excess or deficiency of a whole *comma* without being offended, it is easy to see that some *temperament* must take place, even in using such a simple and limited number of sounds as the above series of eight notes."

To demonstrate the absolute necessity of adopting a system of tempered tuning to enable every one of the major and minor scales to be used in musical composition, and to render them all equally agreeable to the ear, the following facts are advanced:

If the interval of the perfect octave, say, from C (4 ft.) to c^1 (2 ft.), is divided into three perfect major thirds in the ratio 5 to 4; namely, C—E; E—G♯; A♭—c^1, it will be found that the c^1 so arrived at is too flat to form a perfect octave with the first note C by the small quantity termed a *diesis*, expressed, as before stated, by the ratio 128 to 125. Accordingly, as the octave must be absolutely perfect, it is necessary that each major third be sharpened to the extent of one-third of the *diesis*.

If the interval of the perfect octave, say, from C to c^1, as before, be divided into four minor thirds in the ratio 6 to 5; namely, C—E♭; D♯—F♯; F♯—A; A—c^1, it will be found that the c^1 so arrived at is too sharp in the ratio 648 to 625. Accordingly, as the octave must be perfect, it is necessary that the four minor thirds be slightly and equally flattened to the extent demanded by the perfect adjustment of the octave C—c^1.

If the following progressive series of fifths, C—G; G—d^1; d^1—a^1; a^1—e^2, be tuned to the perfect ratio 3 to 2, it will be found that the last note e^2 will form an offensively sharp major third to the super-octave c^2, correctly tuned to the starting note C. Accordingly, it is necessary to flatten each successive fifth sufficiently to render the major third c^2—e^2 approximately perfect, or, more correctly speaking, somewhat sharper than perfect. This proves that if the fifths are tuned perfect, the major thirds will be insufferably sharp; and if the fifths are so mistuned or tempered as to bring the thirds perfect, all the fifths will be too flat for use in harmony.

By the proper and equal tempering of all the intervals throughout the compass of the Organ, with the exception of the octaves, no interval is rendered so flat or so sharp as to be unsuitable in harmony or objectionable to the ear.

In practical tuning according to equal temperament the ear of the tuner is the only agent in the determination of the degree of the departure from absolute

perfection called for in mistuning or tempering all the different intervals comprised within the octave. The ear has only one means of determining the requisite degree of departure in every case: that is by the beats which are generated by any two sounds which are not in perfect accord with each other. Between the octaves throughout the compass of the instrument, absolutely no beats must obtain: the two sounds of each octave must blend into one undisturbed sound. All the other intervals must produce a regular succession of beats consistent with their pitch or position in the compass; that is to say, the beats in any interval will double in number in each successive octave higher in the scale.

There is no difficulty experienced by the normal sensitive ear in hearing the beats generated by any two sounds which do not strictly accord: the real difficulty which confronts the tuner who has not had a long practical experience in his art, is to accurately determine how many beats, with perhaps the fraction of a beat, take place in each second of time; and also to positively determine whether the beats he hears are produced by the interval being more or less than perfect. In the Organ this latter question is easily settled by slightly shading the pipe being tuned. It is, in the first place, essential that the duration of the second of time be firmly recorded in the tuner's mind. This can be done by an attentive and somewhat prolonged reference to a watch provided with a center second-hand; or by the observation of the swings of a pendulum marking, either by a single or a double swing, a second of time.*

The next important matter is to arrive at a clear knowledge of the numbers of beats and the fractions of beats which obtain in all the tempered intervals throughout the compass of the Organ. This is done by a simple process of calculation; and to make this easy for the reader, we give the following Table showing the vibration-numbers of all the semitones comprised in the six octaves from the CCC (16 ft.) note to the b^3 note: First, in the equal-tempered scale according to the philosophical pitch, which gives the note c^1 256 vibrations per second; and, secondly, in the equal-tempered scale according to the Diapason Normal pitch, which gives a^1 435 vibrations per second at the temperature of 15° Centigrade (59° Fahrenheit). It is with the latter scale that we are chiefly concerned at the present time. By the use of this Table, the number of beats and fraction of a beat which must, in equal temperament, be heard in a second of time between the sounds forming any interval within the octave, can be quickly ascertained. In the Table the decimals are carried to three places, but in practice there is no necessity to go beyond two places, while in ordinary cases one is sufficient.

* The most convenient pendulum is that marking seconds by a double swing or a complete to-and-fro movement. Such a time-marker can be easily and quickly made in the following manner: Cut a disc of lead or pipe-metal, about 1½ inches in diameter, and mark its exact center. Then pierce it close to its edge, and attach to it a piece of thread or sewing silk about a foot long. Pass the free end of the thread through a fine hole in a small metal or wood arm, projecting from any convenient support, and tie or otherwise fix it, so that from the under side of the arm to the center of the metal disc the length will be exactly 9⅞ inches. When this pendulum is set in motion, each to-and-fro movement or double swing will invariably be accomplished in a second of time. Such a simple and efficient second-marker will prove of considerable help to the inexperienced tuner.

TABLE OF THE NUMBERS OF VIBRATIONS PER SECOND OF THE NOTES OF SIX OCTAVES IN EQUAL TEMPERAMENT ACCORDING TO THE PHILOSOPHICAL PITCH AND THE DIAPASON NORMAL.—TEMPERATURE 15° CENTIGRADE.

NOTE.	PHILOSOPHICAL PITCH $c^1 = 256$.	DIAPASON NORMAL $a^1 = 435$.	NOTE.	PHILOSOPHICAL PITCH $c^1 = 256$.	DIAPASON NORMAL $a^1 = 435$.	NOTE.	PHILOSOPHICAL PITCH $c^1 = 256$.	DIAPASON NORMAL $a^1 = 435$.
CCC	32·	32·331	C	128·	129·326	c^2	512·	517·305
♯	33·902	34·254	♯	135·611	137·016	♯	542·445	548·066
DDD	35·918	36·290	D	143·675	145·163	d^2	574·700	580·655
♯	38·054	38·449	♯	152·218	153·796	♯	608·874	615·183
EEE	40·317	40·735	E	161·269	162·940	e^2	645·080	651·763
FFF	42·714	43·157	F	170·859	172·629	f^2	683·438	690·519
♯	45·254	45·723	♯	181·019	182·895	♯	724·077	731·580
GGG	47·945	48·442	G	191·783	193·770	g^2	767·133	775·082
♯	50·796	51·323	♯	203·187	205·292	♯	812·749	821·171
AAA	53·817	54·375	A	215·269	217·500	a^2	861·078	870·
♯	57·017	57·608	♯	228·070	230·433	♯	912·280	921·733
BBB	60·407	61·033	B	241·631	244·135	b^2	966·527	976·542
CC	64·	64·663	c^1	256·	258·652	c^3	1024·	1034·610
♯	67·805	68·508	♯	271·222	274·033	♯	1084·890	1096·132
DD	71·837	72·581	d^1	287·350	290·327	d^3	1149·400	1161·310
♯	76·109	76·898	♯	304·437	307·592	♯	1217·748	1230·366
EE	80·634	81·470	e^1	322·539	325·881	e^3	1290·158	1303·526
FF	85·429	86·314	f^1	341·719	345·259	f^3	1366·876	1381·038
♯	90·509	91·447	♯	362·038	365·790	♯	1448·154	1463·160
GG	95·891	96·885	g^1	383·566	387·541	g^3	1534·266	1550·164
♯	101·593	102·646	♯	406·374	410·585	♯	1625·498	1642·342
AA	107·634	108·750	a^1	430·539	435·	a^3	1722·156	1740·
♯	114·035	115·216	♯	456·140	460·866	♯	1824·560	1843·466
BB	120·815	122·067	b^1	483·263	488·271	b^3	1933·054	1953·084

The use of the Table may be illustrated as follows: It is known well that in equal temperament all the fifths must be mistuned a trifle flat, but it is necessary in correctly laying the bearings in any stop to know as nearly as possible what that trifle flat amounts to in the different fifths. In the first place it must be remembered that the ratio of the fifth to the tonic is 2 : 3. Now, referring to the Table, we may take for example the vibration-number of c^1 (in the Diapason Normal column), which is 258·652: this we multiply by 3, giving us 775·956. The fifth above is g^1, having the vibration-number 387·541: this we multiply by 2, giving us 775·082. On subtracting the latter from the former product, we obtain the fraction ·874, or simply ·87, showing that in the interval c^1 to g^1, the latter note must be mistuned $\frac{87}{100}$ of a beat flat. All fifths lower in the scale will require smaller fractions of a whole beat, while fifths higher in the scale will call for flatting exceeding a whole beat in a second of time. For instance, if we take the vibration-number of $e^1 = 325·881$, and multiply it by 3, we have the product

977·643; then if we take the vibration-number of b^1 (the fifth above) = 488·271, and multiply it by 2, we have the product 976·542. Subtracting the latter from the former product, we obtain the difference 1·101, showing that the fifth e^1 to b^1 must be mistuned $1\frac{1}{10}$ beats flatter than perfect. By such simple calculations the degree of flatness (in equal temperament) can be correctly ascertained for every fifth throughout the six octaves given in the Table.

In like manner the Table can be used to decide the degree of sharpness which must obtain in every fourth throughout the six octaves. One example will be sufficient, it being remembered that the ratio of the fourth is 3 : 4. Taking the vibration-number of c^1 = 258·652, and multiplying it by 4, we obtain the product 1034·608. Then taking the vibration-number of f^1 (the fourth above) = 345·259, and multiplying it by 3, we get the product 1035·777. Subtracting the former from the latter, we find the difference to be 1·169, which shows that this fourth—c^1 to f^1—must, in equal temperament, be mistuned practically $1\frac{17}{100}$ beats per second sharper than perfect.

Although in the process of laying the bearings and tuning generally, in equal temperament, it is not necessary to resort to such intervals as the major and minor thirds and the major and minor sixths, save, perhaps, for any desirable tests or proofs of accuracy, the beats and fraction of a beat which obtain in any of these intervals can be immediately ascertained by using the vibration-numbers given in the Table and multiplying them by the proper ratio and subtracting the lesser product from the larger, in the manner set forth below:

MAJOR THIRD—RATIO 5 : 4.

c^1 = 258·652 — e^1 = 325·881

5	4
1293·260	1303·524
	1293·260
Beats per second, sharp,	10·264

MINOR THIRD—RATIO 6 : 5.

c^1 = 258·652 — $d\sharp^1$ = 307·592

6	5
1551·912	1537·960
1537·960	
13·952	Beats per second, flat.

MAJOR SIXTH—RATIO 5 : 3.

c^1 = 258·652 — a^1 = 435·000

5	3
1293·260	1305·000
	1293·260
Beats per second, sharp,	11·740

MINOR SIXTH—RATIO 8 : 5.

c^1 = 258·652 — $g\sharp^1$ = 410·585

8	5
2069·216	2052·925
2052·925	
16·291	Beats per second, flat.

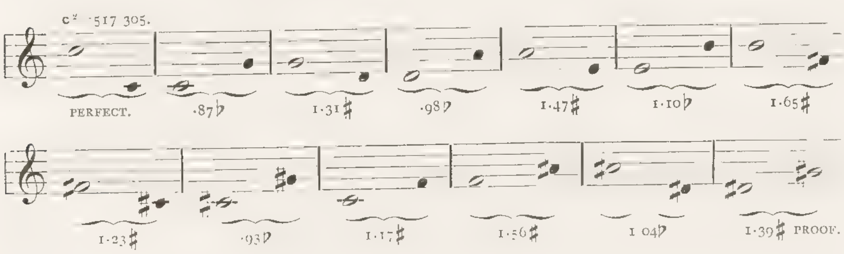
We may now enter on the consideration of the desirable methods of practical tuning in equal temperament. It must be understood that all the pipes of the Organ have been accurately cut to speaking length, regulated, and tuned approximately correct; and that all the pipe-work in the several divisions of the instrument has been sufficiently and uniformly exposed to the surrounding air to secure equal temperature throughout. All swell-boxes should be left fully open for at

least twelve hours previous to the correct tuning. All the interior arrangements of the Organ must be as little disturbed as possible; for it is very necessary that the same conditions should obtain during the process of tuning as will exist when the tuning is finished and the instrument is in playing order. Every precaution must be taken to prevent any local rise of temperature in the pipe-work, whether by the use of artificial lighting by gas, candles, or electric lamps. The last-named are both the least objectionable and the safest in use; but they should be so located as to illuminate without heating the pipe-work. The tuner must be very careful not to remain in one locality very long, and not to approach too near the pipes he is tuning. The heat from his body will affect the pitch of the pipes, while he may so shade the pipes as to render his work very uncertain. In short, if close tuning is aimed at, too many precautions cannot be taken to protect the pipe-work from any modifying influences. It is almost unnecessary to add that if any pipe has to be touched by the hand during the process of tuning, it must be left to return to its normal temperature before its tuning is proceeded with.

In the process of tuning the initial step is to test the pitch, and correctly adjust it to a standard tuning-fork having the proper number of vibrations per second at the temperature at which the Organ is to be tuned and played. The absolute necessity of recognizing the influence of temperature has already been dwelt upon. It is not sufficient to use the ordinary Diapason Normal a^1 fork, having 435 vibrations per second at the moderate temperature of 15° Centigrade, for an Organ standing in a church or concert-room heated to perhaps 20° Centigrade.

When the pitch has been accurately adjusted, the tuner can proceed to "lay the bearings"; that is, to carefully and correctly mistune either one or two octaves on the most suitable stop for the purpose in the Organ. The stop usually selected is the chief OCTAVE, 4 FT., in the principal manual division of the instrument. When laying the bearings is confined to one octave, the middle octave of the clavier is usually selected. When two octaves are used in laying the bearings, the tenor and middle octaves of the clavier are properly selected.

The simplest and in our experience the most satisfactory method of laying the bearings is through the medium of fifths and fourths, as in the following Scheme:



To prevent any confusion arising from the notation, which belongs to the middle octave of the clavier, we have appended the numbers of beats per second which strictly belong to the *unison sounds* represented by the notes. When this

notation is adhered to with the OCTAVE, 4 FT., drawn, the numbers of the beats must be doubled. Reference to the Table of vibration-numbers with the necessary calculations, as explained, will prove these statements to be correct. To render the observation of the beats in the intervals more easy it will be well to count them during ten seconds of time instead of during single seconds. Should the longer time be adopted, it will only be necessary to multiply the numbers given in the above Scheme by ten, the products showing the numbers of beats which occur in each fifth and fourth in the octave.

Supposing the OCTAVE, 4 FT., drawn on the Great Organ manual, and the space of ten seconds adopted in which the varying numbers of the beats in the successive intervals are to be counted, the bearings will be laid in the following manner: Tune middle c^1 (1 ft. pitch) perfectly to a c^2 fork having 517·305 vibrations per second. Then hold middle c^1 with the g^1 above, flatting the pitch of the latter until it produces 17·51 beats flat. Hold g^1 with d^1 below, flatting the latter until the interval becomes 26·26 beats sharp. Hold d^1 with a^1 above, flatting the latter until it produces 19·65 beats flat. Hold a^1 with e^1 below, flatting the latter until the interval becomes 29·50 beats sharp. Hold e^1 with b^1 above, flatting the latter until it produces 22·05 beats flat. Hold b^1 with $f\sharp^1$ below, flatting the latter until the interval becomes 33·06 beats sharp. Hold $f\sharp^1$ with $c\sharp^1$ below, flatting the latter until the interval becomes 24·76 beats sharp. Hold $c\sharp^1$ with $g\sharp^1$ above, flatting the latter until it produces 18·56 beats flat. Hold c^1 with f^1 above, tuning the latter until it produces 23·37 beats sharp. Hold f^1 with $a\sharp^1$ above, tuning the latter until it produces 31·23 beats sharp. Hold $a\sharp^1$ with $d\sharp^1$ below, tuning the latter until the interval becomes 20·83 beats flat. Finally, prove the correctness of the bearings by holding the last-tuned $d\sharp^1$ with the previously-tuned $g\sharp^1$, which fourth, if correct, will be 27·81 beats sharp. Should this fourth be found incorrect all the intervals must be gone over again carefully with the view of detecting where and to what extent the error has crept in.

In the following Scheme the bearings are laid in octaves and fourths through two octaves, as shown by the notation, the initial pitch being taken from an a^1 tuning-fork having 435·00 vibrations per second, in accordance with the Table above given. The OCTAVE, 4 FT., is understood to be drawn, as in the preceding Scheme, and, accordingly, the pitch is taken on the A key of the clavier. From this key the octave a^1 is tuned perfect. Then hold A with d^1 above and tune the latter until it produces 19·65 beats sharp per ten seconds. Tune D to d^1 perfect. Hold d^1 with g^1 above and tune the latter until it produces 26·26 beats sharp. Tune G to g^1 perfect. Hold G with c^1, and tune the latter until it produces 17·51 beats sharp. Tune both C and c^2 to c^1 perfect. Hold c^1 with f^1 above, and tune the latter until it produces 23·37 beats sharp. Tune F to f^1 perfect. Hold F with $A\sharp$ above, and tune the latter until it produces 15·62 beats sharp. Tune $a\sharp^1$ to $A\sharp$ perfect. Hold $A\sharp$ with $d\sharp^1$ above, and tune the latter until it produces 20·85 beats sharp. Tune $D\sharp$ to $d\sharp^1$ perfect. Hold $d\sharp^1$ with $g\sharp^1$ above, and tune the latter until it produces 27·81 beats sharp. Tune $G\sharp$ to $g\sharp^1$ perfect. Hold $G\sharp$ with $c\sharp^1$ above, and tune the latter until it produces 18·58 beats sharp. Tune $C\sharp$ to $c\sharp^1$ perfect. Hold $c\sharp^1$ with $f\sharp^1$ above, and tune the latter until it pro-

duces 24·76 beats sharp. Tune F♯ to f♯¹ perfect. Hold F♯ with B above, and tune the latter until it produces 16·53 beats sharp. Tune b¹ to B perfect. Hold B with e¹ above and tune the latter until it produces 22·05 beats sharp. Tune E to e¹ perfect. Hold e¹ with a¹ above, and tune the latter until it produces 29·48

beats sharp. If the a¹ requires no tuning the bearings have been correctly laid, and it should remain perfect with the pitch note A. Should it be found too sharp or flat, the bearings must be gone over carefully and corrected until the proof is found satisfactory. It will be found on examination of the notation, that by this simple Scheme every note of the chromatic scale from C to c² inclusive is tuned on the Octave, 4 ft.; or at unison pitch (8 ft.) from c¹ to c³ inclusive.

Other schemes or systems of laying the bearings have been followed, but of these it is unnecessary to speak. It becomes a simple matter, through the use of the Table we have given, to devise combinations or modifications of the schemes shown in notation and fully described to suit individual views.

When the bearings have been proved correct, the tuning of other notes of the Octave, 4 ft., can be proceeded with. In tuning upward, hold the first un tuned note—probably c♯²—with its octave below, which has been tuned in laying the bearings, and tune it perfect, testing it along with its fifth and fourth below. If the new note is correct it will beat with both in strict accordance with the calculations arrived at by the vibration-numbers given in our Table, as previously explained. Reference to the fifth and fourth is necessary, because it is somewhat difficult, in the powerful and sustained notes of the organ-stop, for the ear to be certain that an octave is perfect. This process of tuning must be followed in the case of each successive note until the top note of the clavier is reached. Then the notes below the octave or octaves in which the bearings have been laid are to be tuned in precisely the same manner until the CC note is reached. Here, however, each note, tuned to its octave above, must be tested with its fourth and fifth

above. When very close tuning is aimed at, it is very desirable to test the same throughout the compass of the stop, by means of major and minor thirds, minor and major sixths, and tenths, both in single and double octaves. These tests may be made in the form of chords. It is, perhaps, unnecessary to remark that, in close tuning, intervals of rest should be given to the ear, the sensitiveness of which becomes deadened by listening to prolonged and loud sounds without intermission.

When the Octave, 4 ft., of the Great or principal manual division has been correctly tuned, as above directed, the Octave or chief stop of 4 ft. pitch in each of the other divisions should be tuned from it, bearings being laid in each, and all octaves carefully tested by reference to fifths, fourths, and the other testing intervals. All the unisons and other stops in the different divisions of the Organ may now be tuned from the Octaves and the other stops of 4 ft. pitch, care being taken to test the closeness of the tuning by frequent reference to proofs of accuracy. We strongly recommend, however, that all the very delicate-toned stops be accurately pitched, and then tuned independently from bearings laid on them. It is practically impossible to arrive at the close and satisfactory tuning of very soft stops through the direct agency of a loud-toned Octave. We invariably followed this method in the tuning of our own Chamber Organ. No rule of general application can be formulated in this matter. If the tuner is an expert and artist in his calling, his judgment and experience will dictate the best modes of procedure in each case and for different classes of stops. Too much care cannot be expended on the close tuning of an Organ; and neither time nor adequate recompense should be grudged the tuner who does his work conscientiously and thoroughly, and without damaging the pipe-work in any way.

In conclusion, it must be clearly understood that while every rank of pipes extending throughout the compass of the Organ has to be mistuned according to equal temperament, as above directed, all the pipes which speak on each note of that compass must, whatever their pitch or relation to the foundation tone may be, be tuned together absolutely perfect. This positive rule includes all the pipes forming the harmonic-corroborating and compound stops of the Organ. In tuning the numerous ranks which compose the compound stops, too much care cannot be exercised: the intervals formed by the several ranks must be tuned so that not a single beat can be heard when any key is held down.

The different appliances or methods by which labial and lingual pipes are brought into tune are fully described in the Chapters devoted to the Construction of Wood and Metal Pipes.

REGULATING.

By the term Regulating is understood the process by which the pipes forming any single stop are so adjusted one to the other throughout its compass that no one shall be more or less assertive in tone than the others: that when every note is played, in ascending the chromatic scale, from CC to c^4, the ear shall hear a perfectly even intonation throughout, being unable to detect a single sound

varying in strength from the sounds which immediately precede and follow it.

All stops while being voiced are primarily regulated and tuned, otherwise it would be impossible to be certain of their proper tonality throughout their compass. But this regulating is altogether insufficient to meet the exacting demands of the trained ear, or fulfil the requirements of a refined musical instrument. The final regulating must be done when the Organ is erected in its proper place, and can be heard under controlling acoustical conditions. It is seldom one hears an Organ properly regulated throughout; and this can be readily accounted for by the simple fact that skilful and artistic regulating calls for strained attention and the expenditure of much time. The latter, organ builders are commonly reluctant to indulge in; while the former is largely out of fashion in this epoch of competitive organ-building. Things would be different were purchasers of Organs thoroughly conversant with the nature and tonal powers of the instruments they pay for, and were more liberal in the matter of the purchase money.

Providing the pipes of any stop have been artistically voiced and accurately cut to length, the final regulating seldom calls for more than the careful adjustment of the wind supply at their feet—a simple process, but one that demands, as we have already said, strained attention on the part of the ear, and the expenditure of considerable time. Such regulating accompanies close tuning; and as every metal pipe that is removed to be regulated has to be left a sufficient time to become thoroughly cold before its tuning can be completed, it is easy to understand how tedious the process of regulating may become under artistic guidance. Indeed, time must not be taken into consideration. To keep an Organ in perfect order tonally, a certain amount of regulating should accompany every tuning the instrument undergoes.

While the process above outlined is commonly understood to be signified by the term Regulating, there is another and much higher process that has an equal, if not a greater, right to be embraced by the term. We allude to the regulating of the voices of all the stops or ranks of pipes in an Organ with respect to the foundation and to each other. It is beyond question that this higher and scientific process of tonal regulating is almost a dead letter in this epoch of commercial organ-building. It is true that the more thoughtful and artistic organ builders pay some attention to the relative scaling of the stops to be inserted in their Organs, and follow, more or less as a matter of common practice, some scheme of tonal relationship and balance: but where are they who to-day look upon this all-important matter of tonal balance and relationship and all they imply as the highest walk of their noble art, lighted on the one hand by the cold rays of scientific teaching, and on the other hand by the warm rays of musical taste? If an organ builder is not a fairly accomplished acoustician, and does not possess a keen sense of the values of musical tones and their combinational properties, he is simply a machine so far as his art is concerned—a navigator of a vessel on which there is no compass, in a sea for which he has no chart. This may be an unpleasant fact, but a fact nevertheless.

However large an Organ may be, in the eye of science it is simply a GRAND MIXTURE, in which every stop or rank of pipes has its appointed place and office.

While certain stops occupy more prominent positions in the grand tonal scheme than others, and while some appear to be lost in their insignificance, not one can be neglected or mistreated without injury to the whole. Just as scientific regulating is imperative in all the ranks of a compound harmonic-corroborating stop, so is scientific and artistic regulating imperative in all the stops which form the grand tonal scheme of an Organ. On these important subjects full information will be found in our Chapters on the Tonal Structure of the Organ and the Compound Stops of the Organ, and also, to some extent, in the Chapter on the Tonal Appointment of the Organ.

On perfect regulating, in the full sense and scope of the term, depends the beauty and value of the Organ as a musical instrument.

CHAPTER XLI.

THE TREMOLANT.

THE small mechanical appliance known as the Tremolant or Tremulant is found in the generality of modern Organs of any importance, where it is introduced for the purpose of imparting a tremulous or undulatory effect to the tones or speech of certain stops at the will of the performer.

While nothing, perhaps, in the entire range of organ effects becomes more monotonous and irritating to the cultivated musical ear than the over-use or the abuse of the *tremolando*, the legitimate and artistic use of the tremolant is neither to be condemned nor discouraged. It imparts a pleasing character to the voices of certain stops of delicate intonation, especially in their middle register, in passages of a vocal or melodic character. Unless the appliance is most skilfully made and most carefully adjusted, it has a decided tendency to confuse the bass notes, and to disturb, if not altogether destroy the clear intonation of the pipes in the higher octaves of the manual compass. The tremolant is a necessary appendage to the so-called Vox Humana; for without the *vibrato* effect the stop fails to convey the slightest idea of the human voice: even with it, the stop, in its very best form, and under the most favorable conditions acoustically, produces a poor imitation, accompanied by the most inartistic and distressing failing the human voice can well have; namely, a perpetual *vibrato*—the failing of too many public singers.

The date of the introduction of the tremolant in the Organ is not clearly known; but it, or something answering a similar purpose, was in use in the opening years of the seventeenth century in England. In the accounts for the Organ made by Dallam, in 1606, for King's College Chapel, Cambridge, we find the item, "For brasse for the shaking stoppe, iiij*s*." In the "bargain" made in 1665 by John Loosemore with Sir George Trevilyan, for what was apparently a Chamber Organ of eight stops, we find "One Shaking Stopp" of metal. Whether these

were mechanical appliances affecting the entire Organs, or something connected with the individual stops, called "shaking stops," has not been decided. A "Trimeloe" was introduced in the Organ built by Smith for St. Mary-at-Hill in 1693, and another was inserted in the first Organ in the Lutheran Church, Savoy, Strand, London. Of these old appliances we know nothing; but we may conclude that they were unsatisfactory from the fact that they did not come into general use either in England or on the Continent. The *tremolando* was, however, first heard on the Organ. In Grassineau's "Musical Dictionary," published in 1740, the following passage appears:

> "TREMOLO, *Tremolante*, or *Tremente*, 'tis not often used, except thus abbreviated *Trem.* or *Tr.*, to intimate to the instrumental performers of a piece, that they make several notes on the same degree or pitch of tune, with one draw of the bow, to imitate the shaking on the Organ. Tho' this is often placed in the vocal parts of a song."

Judging from the information afforded by such a treatise as that by Dom Bedos, it appears evident that up to the date of its publication (1766) the tremolant was both a clumsy and uncertain appliance. This great authority on the older school of organ-building says: "Il y a dans l'Orgue le plus ordinairement deux *Tremblants*, l'un appellé le *Tremblant doux*, & l'autre nommé le *Tremblant fort*, que quelques-uns appellent le *Tremblant à vent perdu*, parce qu'il se perd un peu de vent lorsqu'il joue."

The *Tremblant doux* was an appliance placed inside an enlarged portion of the main wind-trunk, adjoining the bellows, and from its construction must have been very uncertain and weak in action.*

The *Tremblant fort* was a piece of mechanism somewhat resembling in principle the ordinary form of the modern tremolant.† It was placed in one of the sides of a vertical wind-trunk, and consisted of a box or frame of wood having a square valve or pallet, covered with leather, hung at each end. The valve which opened inwardly, in the wind-trunk, hung vertically, and was held against its seat by a pallet-spring. This was drawn from its seat by a wire, partly formed as a spiral spring, which passed through a leather purse in the opposite side of the wind-trunk. The external valve rested against an inclined seat and was weighted to keep it closed. When the pull-wire with its spiral spring drew the internal valve from its seat, the compressed air in the wind-trunk rushing into the box raised the weighted external valve and escaped. This sudden draught favored the closing of the internal valve, which was subjected to pressure on its inner surface only, the spiral spring allowing it to reach its seat. The external valve, entirely relieved from the force of the compressed air, immediately closed, and at the same

* "Le Tremblant doux consiste en une Soupape garnie d'un poids attaché au bout d'un ressort, renfermée dans le grand Porte-vent, laquelle étant comme suspendue en opposition au passage du vent, & surmontée dans son poids & sa résistance par celui-ci, nage, pour ainsi dire, sur son cours, le modifie & lui communique une sorte de *balancement* ou de *libration* qui se transmet au son des tuyaux."

† "Le Tremblant fort consiste en deux Soupapes posées dans une situation réciproquement opposée, qui, étant agitées par le vent, lui communiquent un mouvement de trépidation qui se fait sentir dans le son des tuyaux." L'Art du Facteur d'Orgues," pp. 124 and 126.

instant the internal valve was again drawn from its seat by the pull of the spiral spring, and the action, as just described, was repeated. The puffs of air which this appliance permitted to escape at regular intervals communicated a pulsation to the wind of the Organ, and caused the speech of the pipe-work to tremble. This appliance was correctly distinguished by the name "*Tremblant à vent perdu.*"

One is somewhat surprised to find in the most important German treatise on the art of organ-building, published so lately as 1888,* nothing more modern, so far as the tremolant is concerned, than the insufficient and old-fashioned appliances described by Dom Bedos, whose illustrations have been simply copied without acknowledgment.

We may now direct attention to the representative forms of modern tremolants. In Organs of moderate size and ordinary construction, only one tremolant is introduced, and it is almost invariably attached to the Swell division in which the Vox Humana (when there is one) and the other stops best adapted to its influence are located. In larger instruments, which have more than one expressive division, it is usual and proper to find a tremolant attached to each, affecting in some cases the whole and in others only a certain number of the inclosed stops. In the Grand Organ in St. George's Hall, Liverpool, there are now two tremolants, attached to the Swell and the expressive section of the Solo Organ, in which latter the Vox Humana has recently been placed, having been removed from the original Swell Organ. In the Concert Organ in the Public Halls, Glasgow, there are also two tremolants, one of which is attached to the Swell division, and the other to the expressive section of the Choir division, containing the Vox Humana and Clarinet. M. Cavaillé-Coll has attached tremolants to the Swell and Choir divisions of his Organ in the Albert Hall, Sheffield. Both divisions are, of course, expressive. In Mr. Roosevelt's large Concert Organ in the Auditorium at Chicago there are five expressive divisions; and tremolants are attached to the Swell, Choir, Solo, and Echo Organs.

Although modern tremolants vary in their construction, the same result is aimed at in all; namely, by their mechanical action, to set up regular and uniform pulsations in the body of compressed air contained in the wind-chest or supplied to the pipe-work. In all such tremolants the effect desired is produced, as in the case of the "*Tremblant à vent perdu,*" by permitting puffs of the compressed air to escape and suddenly checking, or cutting them off, at equal intervals of time. The most satisfactory tremolant is, of course, the one which does this with the minimum of noise and vibratory motion in its action.

Notwithstanding the fact that even in this somewhat advanced epoch of the organ builder's art a really satisfactory tremolant is rarely met with, one cannot help wondering at Seidel's remarks on the "shaking stop." This worthy old organist of Breslau, writing about the year 1844, and alluding to certain curiosities of organ-building, says: "Another absurd and even pernicious contrivance is the Tremolando, a register which, in funeral services, on fast days, and on Good Fri-

* Die Theorie und Praxis des Orgelbaues. Zweite völlig umgearbeitete Auflage des Lehrbuches der Orgelbaukunst von J. G. Töpfer. Für den Gebrauch des Orgelbauers, Orgelrevisors, Organisten und Architekten herausgegeben von Max Allihn. Weimar, 1888.

day, was used to indicate the sobbing, sighing, and trembling of men." Of a tremolant, or "pernicious contrivance," capable of such doleful and realistic effects, we fortunately know nothing, although we have heard many tremolants that completely destroyed the tones they were expected to beautify, with their puffing and thumping.

It is quite unnecessary for us to devote valuable space to the description of the tentative forms of the bellows and pallet tremolant, which were used by English organ builders during the first half of the nineteenth century, the first improvement on which was made by the late Mr. Henry Willis, of London, and patented by him in 1853. The reader who may feel interested in these tentative essays will do well to consult Mr. Willis' Patent Specification.*

The tremolant we have now to describe, while it is constructed on a somewhat similar principle to that which obtains in the early bellows and pallet tremolants, is decidedly superior in every respect to all such tentative works. When properly made and carefully regulated, it is practically noiseless in action, and owing to the fact that no absolute contact or blow takes place in any part of its mechanism, very little vibration is generated. Its pulsations are powerful and clearly marked, without being jerky and destructive of the most delicate tones. It can be regulated to any desirable speed; and it is perfectly efficient when located at a considerable distance from the wind-chest. The construction of this tremolant is clearly shown by the Longitudinal Section (1), Transverse Section (2), and Top View (3) given in Fig. I., Plate X.

The larger portion of the appliance consists of the two chambers A and H, the lower one of which is connected with the associated wind-chest by a conveyance, about 2½ inches in diameter, and is constantly filled with the organ-wind while the Organ is being used. The entry of the conveyance is indicated at B. The oblong opening D is cut in the board which divides the chambers A and H, to allow the organ-wind to enter the chamber H when the pallet C is drawn down, as indicated in both the Sections. This pallet is commanded by the pull-down wire E, which is attached, by any suitable mechanical or pneumatic action, to the draw-stop knob, touch, or lever. This pallet and its accessories resemble those of the old-fashioned wind-chest, and require no special description. The upper chamber H has the oblong opening I cut through its top board for the passage of the wind into the superposed bellows K. L is a valve or pallet extending over the opening I, felted and leathered on its face, and so tightly bound by its tail-slip U that it can be completely closed only by a considerable pull, and which, accordingly, is never so closed under the ordinary action of the appliance. The bellows K has stationary and movable boards, hinged at one end, and otherwise connected with leather-covered cardboard ribs or folds, as indicated. Its stationary board is perforated with the oblong opening J, corresponding with that of the chamber H. The movable board M is perforated with three holes of the forms and dimensions shown in the Top View (3). The two larger ones N and O are for the puffs of compressed air to escape through, while the smaller one P is for the free passage

* "Organs and Free-reed instruments." English Letters Patent No. 2,634, dated November 14, 1853.

PLATE X.

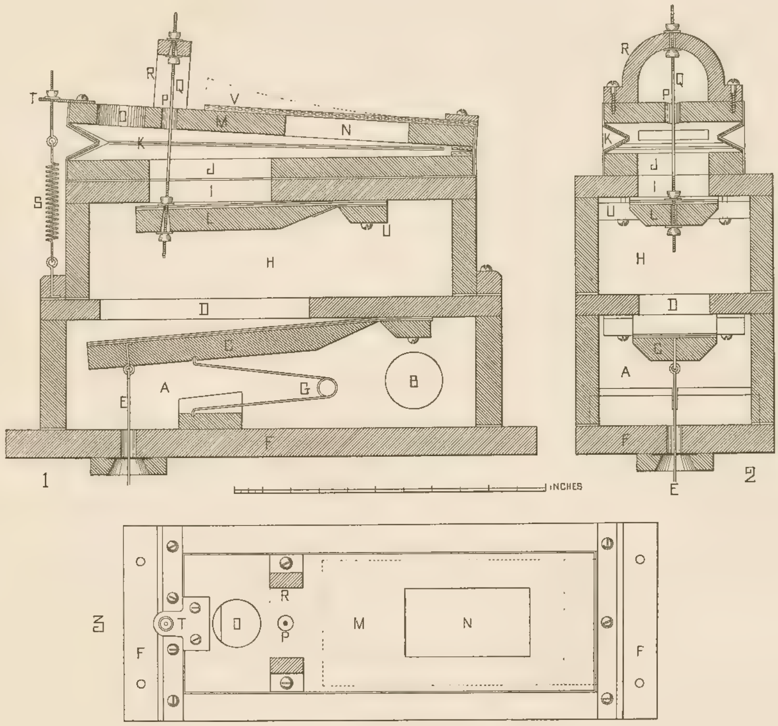


FIG. I.

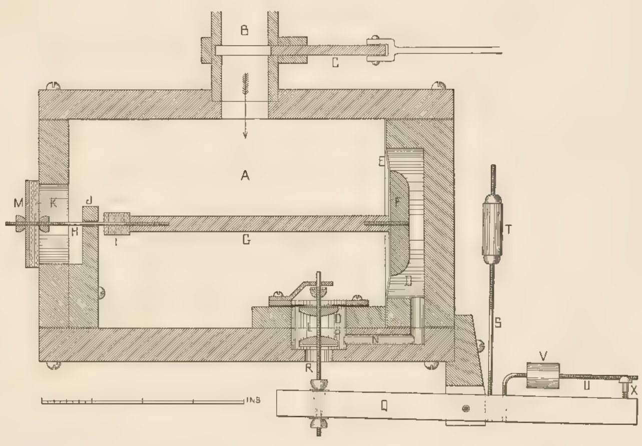


FIG. II.

of the tapped-wire Q, which connects the pallet L with the bridge R of the bellows. It will be seen, on reference to the illustration, that the bridge R is screwed to the movable board M, and, accordingly, partakes of its motion; and, further, that by means of the wire Q and its four holding buttons, adjusted as shown, the pallet L is linked to, and follows the motion of the bridge. S is a fine and very elastic spiral spring of steel, fixed at its lower end, and hooked at its upper end to the adjusting wire which passes through the small projecting lug T, fixed to the movable board of the bellows. Lying on the movable board, and held at its end adjoining the hinge of the bellows, is the flap of fine felt V. Its size and the manner in which it extends around the opening N are indicated by the dotted outline on the Top View (3).

The action of this tremolant is as follows: When the compressed air or organ-wind is admitted into the upper chamber H, by pulling down the pallet C, it finds the pallet L open and the bellows K collapsed under its own weight and the downward pull of the spring S: it immediately rushes through the openings I and J, and not finding a sufficient means of escape it expands the bellows, and at the same time cuts off the supply by almost closing the linked pallet L, as indicated in the Sections. The compressed air, which inflated the bellows, now issues in a puff through the openings O and N, lifting the felt flap V from the latter in the manner indicated by the dotted line in the Longitudinal Section (1). As all pressure is now removed from the bellows, and the spring S is exerting considerable pulling force, the bellows instantly collapses and pushes open the pallet L, again admitting a stream of compressed air. The bellows, in this manner, alternately expands and collapses without causing any absolute contact in any of the moving parts; and each puff of wind it delivers communicates a corresponding pulsation in the entire volume of organ-wind.

The drawings given in Fig. I., Plate X. have been accurately made to scale from the tremolant we constructed for our own Chamber Organ. To secure absolute absence of vibration, and to prevent even the slight noise of the puffs being audible, the tremolant was screwed down to a block of stone, resting on a strong wooden support with thick felt between; and was covered with a box of thick wood, lined with felt, and perforated with some small holes for the escape of the wind issuing from the tremolant. The lower chamber A was connected with the pallet-box of the wind-chest by a metal conveyance 2 inches in diameter and about 3 feet in length. The flow of wind to the tremolant was controlled by a small slider of wood. This tremolant was perfectly silent, whilst its smooth effect on the most delicate voices of the Organ left nothing to be desired.* The wind-pressure was only 2⅜ inches.

Judging by the perfect action of this tremolant, and the small size of its bellows—9 inches by 3 inches—we are convinced that, as a general rule, tremolants are made much too large. Under no conditions need one of this description be made more than 11 inches in length.

*The well-known and accomplished Concert Organist, Mr. Clarence Eddy, speaking of this identical tremolant, in a letter to the Author says: "The Tremolo is absolutely perfect. I do not remember ever to have heard one so quiet and at the same time so efficient."

In fitting to the Organ a tremolant of the class above described, it is absolutely necessary to provide some convenient means of apportioning the supply of wind to it, so as to regulate its speed and the power of the pulsations generated by it. A small slide, constructed to pass across the opening in either the wind-chest or in the chamber of the tremolant, will be sufficient for this purpose. In many instances it may be desirable to have the tremolant located at a considerable distance from the wind-chest it affects, both on account of the difficulty of finding a suitable place for it in the Organ, and for the purpose of removing it as far as possible out of hearing. There is no objection to a distant position, for a properly-constructed and -adjusted tremolant will act as well at a reasonable distance from the wind-chest as it will immediately attached to it, the connection to be made by a small wind-trunk or a metal conveyance of not less than 2 inches in diameter. Every possible precaution must be taken to prevent vibrations or tremblings being communicated by the tremolant to the woodwork of the Organ. The jarrings and tremblings in rods, boards, panels, etc., which too often accompany the use of the tremolant, are objectionable and irritating in the extreme. It is advisable to disconnect (save by the conveyance) the tremolant from all the woodwork of the Organ, and to fix it very firmly to an independent support, preferably to a block of stone, or to a stone or brick wall, which will be sufficient to resist the vibrations and deaden the throbbings of the most energetic apparatus of the kind. We dwell upon these details somewhat, because we are aware how many bad results have accompanied the neglect of proper precautions, and how distressing to the musical ear are the thumpings and pantings of a badly-constructed and -mounted tremolant, heard above the musical sounds of the Organ.

In Fig. II., Plate X., is given a Longitudinal Section of a highly ingenious pneumatic valve and diaphragm tremolant, invented by the late Mr. Ira Bassett, Organ Builder, of Chicago, Ill. It consists of the oblong chamber A, into which the organ-wind is admitted through the square trunk or conveyance B when the slide C is moved by the draw-stop action into the position shown. In the thick end of the chamber is formed the circular recess D; and extending over this is the leather diaphragm E, glued around its edges to the wood of the end, and in its central portion to the wooden disc F. Extending horizontally from the center of this disc is the rod G, which is prolonged by the tapped-wire H and the several soft felt discs I. The tapped-wire is supported by passing through the guide J, and extends through the circular orifice K, on the outside of which it carries the large disc-valve M, formed of stout millboard faced with thick and springy felt. In the bottom boards of the chamber are formed the valve-throat L and the duct N, the latter leading to the cavity D behind the diaphragm E. In the valve-throat are placed the small disc-valves O and P, carried on the valve-stem which rises from the end of the rocking lever Q. The upper valve O commands an opening in a firm leather seat in the manner indicated, while the lower valve P commands the orifice R, which communicates with the open air. The outer arm of the rocking lever Q carries the vertical tapped-wire S, on which is the adjustable weight T; and also the horizontal tapped-wire U, on which is the adjustable weight V. The end of this wire is held in a groove in the head of the screw X.

The appliance is adjusted by means of the weights T and V. The weight V is used to adjust the balance necessary for the proper action of the rocking lever Q, while the weight T governs the speed of the tremolant. The lower this weight is fixed on the wire S, the quicker will the pulsations be, and vice versa. When properly adjusted, the action of the tremolant is as follows: When the pipe- or organ-wind is suddenly admitted by drawing the slide C, it presses against the diaphragm E, driving it inward and closing the external valve M, as shown in the Section. Immediately afterwards it acts on the upper disc-valve O, pressing it and its associated disc-valve P downward, opening the duct N to the chamber A,

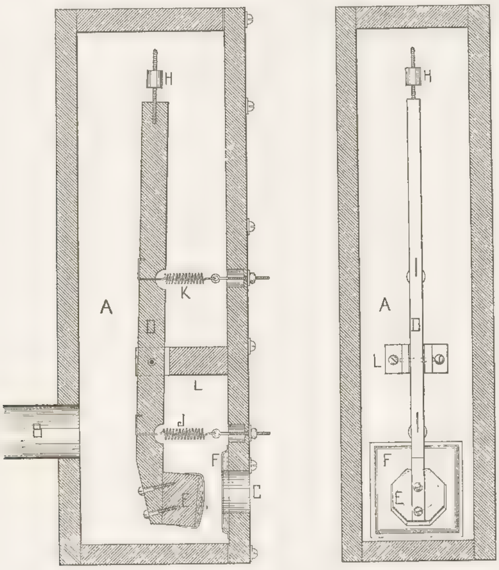


Fig. CCCLXIV.

and closing the valve-throat to the open air. The organ-wind rushes through the duct N and thence into the circular recess D, instituting an equilibrium on both sides of the diaphragm E. This allows the wind to blow open the large valve M and escape into the open air for an instant. The pressure in the chamber A being relaxed, the disc-valves return, through the swing of the rocking lever, to the position shown, the diaphragm is again pressed inward, and the valve M is closed. The action of all the parts is repeated as above described, and a regular succession of puffs of wind issue from the orifice K, creating a periodic concussion as the valve M suddenly closes, and sending a pulsation through all the organ-wind affected by the tremolant. A pulsation, accordingly, occurs at each swing of the rocking lever Q and its regulators.

We have now to direct attention to a simple form of tremolant, constructed on a principle entirely different from that which obtains in the bellows tremolants above spoken of. From the manner in which it is constructed and operates, it may be called the reciprocating-valve or pendular-valve tremolant. Its formation will be readily understood from the illustrations given in Fig. CCCLXIV. It consists of a box or chamber A, into which the organ-wind is admitted through the conveyance B, when the tremolant is brought into action at the will of the performer. In the opposite side of the box is bored the hole C, which places the chamber A in communication with the external air. This hole is thickly padded with soft felt and leather around its edge on the inside, as indicated at F in both drawings. Pivoted to the rigid support L is the wooden bar D, carrying at its lower end the pendular valve E, and at its upper end the adjustable lead weight H. The bar D is held in the normal position shown by the two elastic spiral springs J and K, adjusted to the requisite tension by the tapped-wires and external buttons. The valve E is an octagonal block of light wood, thickly padded with soft felt and faced with pallet leather, as indicated at I. When the organ-wind from the wind-chest or ventil-box is suddenly admitted to the chamber A through the conveyance B, it rushes with full force under the valve E, and through the hole C, instituting a condition there which induces the valve to swing toward, and ultimately strike, the padded orifice, practically closing it for an instant. The valve rebounds under the force of the blow, the cessation of the wind-rush, and the recovering power of the upper spring K. The original conditions again obtain, and the valve immediately moves toward the hole again, only to repeat its return action. A regular swinging motion is imparted to the rod and valve, permitting sharp puffs of the organ-wind to issue through the hole C, and generating a corresponding pulsation in the entire volume of the organ-wind which is under the influence of the tremolant.*

We have now to consider briefly the different methods employed to bring the tremolant into operation at the will of the performer. The most common, and at the same time the most inconvenient, method is by means of the ordinary draw-stop knob; at all events it is inconvenient if it is the only method provided. When other methods are introduced there is no objection to having the tremolant also commanded by a draw-stop knob or some equivalent. Indeed, under certain conditions, there is a positive advantage in such an arrangement. When the draw-stop is adopted for the tremolant, it should be located in some convenient spot adjoining the clavier to which it belongs. Perhaps, as a rule, its proper place is among the knobs of the division it directly affects; and there it should adjoin the knob of the speaking stop with which it will be most frequently used. When there is a Vox Humana in the Organ it is obvious that the tremolant knob should be placed alongside the one which draws that characteristic stop. By this arrangement both the knobs can be manipulated at the same instant. Perhaps, with the single exception of the Vox Humana, there is no stop in the Organ

* The drawings given in Fig. CCCLXIV. have been made from an actual tremolant furnished us by Mr. Philipp Wirsching, Organ Builder, of Salem, Ohio.

which requires the tremolant continuously, and this should be borne in mind in locating the draw-knob. These remarks apply equally to stop-keys or touches of any description in tubular-pneumatic or electro-pneumatic Organs.

In Organs of any pretensions a second method of bringing on the tremolant should be provided, and that quite independent of the general draw-stop action, as above mentioned. The simplest form for this second attachment is a small hitch-down, or a double-acting, foot-lever, placed close to the Swell Organ expression-lever, or to the expression-lever of the division affected by the tremolant. This foot lever should command the tremolant independently of the draw-stop action. On depressing the hitch-down lever, the *tremolando* may be given to a few notes at will, and with an artistic and pleasing effect.

With the view of obtaining this passing or temporary effect of *tremolando* in combination with a *crescendo* or *diminuendo*, arrangements should be made so that the foot resting on the expression-lever can also move another lever connected with the tremolant. The simplest way of doing this is to place the latter in a vertical position, in the form of a hanging rod, resting against one edge of the expression-lever. The expression-lever can be moved by the foot, placed directly upon it, without moving the vertical rod; but if the foot is pressed sidewise against the rod, whilst it moves the expression-lever, the tremolant is at once brought into action. Several modifications of this simple expedient may be adopted to suit special cases. When there are two or more expressive divisions, furnished with independent tremolants, a rod should be provided adjoining each expression-lever. The rods should not require to move more than half an inch to start their tremolants, otherwise the lateral movement of the foot would be inconvenient. The rods should require a reasonable amount of pressure to move them, so that they are not liable to be accidentally moved by the foot whilst it is simply operating the expression-lever. When there are two balanced expression-levers, placed side by side so as to enable the foot to operate them simultaneously, it is obvious that the two tremolant rods must be placed laterally, one on the right of the right lever and one on the left of the other, leaving the small space between the levers clear and unobstructed. Instead of vertical rods, which may not always prove convenient when balanced expression-levers are introduced, a simple action of a lever character may be attached to the outer edge of each expression-lever, which will convey a pressure of the foot to a horizontal rod placed opposite the axis, or through the axle, of the expression-lever, and thence to a pneumatic action controlling the tremolant. By this arrangement the appliance will always be available, and in the same relative position to the foot, whatever the angle of the expression-lever may be. It must be pointed out that when the arrangement just alluded to is carried out, it is necessary to have a manual draw-stop attachment provided for each tremolant, quite independent of the foot action; for when a continuous or protracted *tremolando* is required, the tremolant must be brought on by the manual attachment. The foot action will remain inoperative so long as the manual one is drawn. The best form of tremolant for such compound action is that illustrated in Fig. I., Plate X.; and it is only necessary to have two pallets, C, provided in the lower chamber A: one commanded by the manual attachment and the other by the foot-lever action.

For the purpose of having the tremolant under the immediate control of the performer's hands for occasional effects, certain expedients have been resorted to. One is a long slip of wood, fitted with a spring parallel action, and placed, slightly projecting, in the slip under the manual clavier. When this is pressed by the thumb of either hand, the tremolant instantly responds and continues to act so long as the pressure is retained. This system is, however, inconvenient, and cannot be adopted in claviers furnished with pneumatic combination pistons. The tremolant can of course be commanded by an on-and-off piston action, and such an action is to be recommended under favorable conditions. Of the other expedients which have been suggested and adopted to bring the tremolant into operation at the will of the performer, such as a double-touch on the claviers; elastic tubes to be held in the mouth and blown into when a *tremolando* is desired; and levers of various kinds, to be pressed against by some part of the performer's body, exclusive of hands and feet, nothing need be said here: they may take their places among the curiosities of organ-building.

Before concluding the present Chapter, there is one other matter which must be mentioned. When any division of the Organ has a concussion bellows attached to its wind-trunk, it is a matter of the greatest difficulty, if it is not altogether an impossibility, to get a tremolant of the bellows class to act, for the one appliance counteracts the other. Under these circumstances, it is necessary to attach to the concussion bellows an apparatus which will come into operation only when the tremolant is drawn, and which will immediately fix the concussion bellows at its point of full inflation. There are many ways of doing this which will suggest themselves to the ingenious organ builder. An efficient appliance has been introduced by Mr. Henry Willis in his Organ in Glasgow Cathedral.

CHAPTER XLII.

CONSTRUCTION OF THE SWELL-BOX.

THE proper construction of the Swell-box is a matter of the greatest importance, and yet it is very commonly misunderstood and very often neglected. Its importance becomes obvious when it is realized that a badly-proportioned and improperly-fabricated swell-box never fails to destroy much of the effect and beauty of the tonal forces inclosed therein. We have said in our Chapter on the Swell in the Organ that the belief, which prevails in certain quarters, that the swell-box is destructive of the sounds of the inclosed pipe-work is not without some foundation; and that the foundation for the belief has been furnished by the mistakes and misconceptions of organ builders, and not by anything essentially inherent in the swell-box *per se.* We have also stated that stops inclosed in swell-boxes undergo a certain tonal modification; pointing out the fact that when the swell-boxes are properly proportioned and constructed, and the stops are correctly spaced and planted on wind-chests of ample size, and scientifically scaled and artistically voiced for the position they occupy, the slight modification their voices undergo is an improvement rather than the reverse.

It is somewhat remarkable that in the design and construction of the swell-box—a portion of the Organ which would naturally be expected to have long before this late date assumed a definite and well-established treatment—so many diverse and conflicting views and methods should obtain among organ builders today. That all can be right is impossible, seeing that there can be only one correct mode of treatment in the case of an object which has practically only one office to fulfil, alike in every Organ, large or small.

There are certain causes for the unsatisfactory state of the swell-box in modern Organs, and these we shall briefly touch upon. First, the pretty general ambition on the part of church authorities and organists to have large Organs erected in places totally insufficient for the reception of instruments of moderate dimensions,

has led to the cramming of numerous speaking stops into swell-boxes in every way inadequate for their proper accommodation. Not only, in such cases, are the swell-boxes too small, but the wind-chests which they inclose are so crowded with pipe-work that pure and effective intonation is out of the question. The combination of overcrowded pipe-work and small swell-boxes can only have one result—the serious impairment of the tonal qualities of the divisions of the Organ so maltreated. There are other, and external causes of failure, the chief of which will probably be the crowding of exposed pipe-work, belonging to the Great or some other uninclosed division of the Organ, directly in front of the shutters of the swell-box, materially interfering with the free egress of the sound that does issue from its overcrowded interior. These three adverse conditions obtain in a vast number of modern Organs; and when their internal economy is examined, it seems wonderful that they are capable of producing any expressive musical effects. It is in works of this inartistic and insufficient class that the objection to the extended introduction of the swell-box has had its origin.

Secondly, the very general impression that a swell-box should be so constructed as to impart to the sounds of the inclosed stops the effect of extreme distance, almost amounting to total annihilation, has been attended with very serious results. Organ builders have taxed their ingenuity and skill to produce swell-boxes with thick, composite walls, as impervious to sound as wood, sawdust, felt, and other deadening materials could make them. Every fresh endeavor in this direction made the swell-box a degree more objectionable from the musical point of view. Swell-boxes constructed on any such lines are radically wrong—the essays of men who have altogether misconceived the legitimate and artistic office of the swell in the Organ.

Thirdly, the conviction that, next to inordinately thick and deadened walls, it is most desirable to have every portion of the swell-box made and fitted as air-tight as practicable, has combined with other mistaken ideas to foster wrong principles of construction. It stands to reason that in a confined space like that of a small swell-box, crammed full of pipes, and with tightly-closed shutters, a flatting effect must quickly show itself in the tones of the speaking pipes. Much more air, under a certain pressure, finds its way, through the pipe-work, into the swell-box, than can find its way out while the shutters remain closed: accordingly, it becomes almost impossible to use the inclosed division of the Organ without opening the shutters more or less. This fact in itself shows that there is something wrong in the construction of the swell-box, very seriously impairing its utility. The musical effect of a properly-constructed swell-box should be as satisfactory to the ear when the box is closed as when it is open; and every practical expedient should be resorted to, to secure this important result.

The golden rules of swell-box construction may be thus formulated:

I. *Let the swell-box be designed on as large a scale as the space available for the Organ will permit, and under no conditions let its height be denuded.*

A roomy swell-box is under all conditions an advantage; but it only reaches its highest excellence when it incloses a spacious wind-chest, on which the ranks of pipes stand a sufficient distance apart to allow them to speak freely and with-

out strained intonation, and to admit of the unobstructed egress of their sounds. In Organs of important dimensions, the swell-box should be sufficiently large in plan to allow the pipe-work to stand perfectly free from its sides; and in all possible cases enough space should be provided around the pipe-work to permit easy access to all parts of the same for tuning, regulating, and cleaning. The banking up of the larger pipes (especially those of wood) against the woodwork of the box, preventing the desirable reflection of sound by the inner surface of the walls, is a practice to be strongly condemned on acoustical grounds. It is, unfortunately, almost unavoidable in small and overcrowded swell-boxes. Next in importance to ample space in plan is ample height above the larger pipe-work. This increases the acoustical property of the swell-box, prevents the flatting of the tones of the pipes, and permits the formation of a large area of shutter-work, thereby doing away with the objection, in one direction, which has been reasonably urged against badly-designed swell-boxes; namely, that they seriously impair the tonal quality of the inclosed stops. It is necessary, when the box is high, that the shutters be carried up to as near its roof as possible, so that there may be no locking in of sound above. The reed stops, especially, gain brilliancy by this treatment.

II. *Let the walls and roof of the swell-box be constructed of solid wood of the best quality and of proper thickness, without any packing or other expedient to render them dead and impervious to sound.*

Under this rule, we have to consider the wood most suitable for the construction of the swell-box; and also the thickness of the solid wood necessary to secure the maximum softness of effect, without any destruction of the tonal character of the inclosed speaking stops, when the swell is closed.

Of all woods the most suitable for the construction of the walls and roof of the swell-box is clean, straight-grained white pine; but the best straight-grained yellow or pitch pine is highly to be recommended. Both these woods can be depended upon when perfectly seasoned and free from sapwood, shakes, and other imperfections. For the shutters only the very finest and lightest kind of white pine should be used. Of the modes of constructing the walls, shutters, etc., we treat further on.

On the question of the thickness of the swell-box a considerable diversity of opinion obtains among organ builders: but we feel sure if they would use more observation and independent judgment in matters connected with their art, this diversity of opinion would soon disappear. Several builders advocate the adoption of walls of inordinate thickness, formed of two layers of wood, stuffed between with sawdust, or separated by plies of coarse, thick felt. Such walls are made three or four inches thick, and are about as dead and impervious to sound as a brick wall. Such a thickness as the minimum above named would be bad enough if in solid wood, but in the composite form with sawdust or felt is absolutely fatal to the proper effect of the swell. When formed of solid white pine, the walls and roof should never, even in the largest swell-box likely to be made, exceed two inches in thickness; while for swell-boxes of the ordinary dimensions, one and three-quarter inches for white pine, and one and a half inches for yellow pine, are ample thicknesses. We believe we are correct in stating that the organ

builder who most favored the multiplication of the swell in the Organ held the same views. The finest swell known to us, so far as acoustical and musical properties are concerned, is formed of white pine one and a half inches in thickness.

III. *Let the swell-box have the largest area devoted to shutters consistent with the nature and office of the tonal forces inclosed by it.*

This rule provides for the proper proportion of shutter area to solid woodwork in the swell-boxes of the different divisions of the Organ to which powers of expression may be given. As we have shown in preceding Chapters, the swell-box may with great advantage be applied to sections of the pipe-work of the Great and Pedal Organs, and to the entire tonal forces of the Choir, Swell, and Solo Organs. Such being the case, we may now point out the fact that, while all that has been said under the first and second rules, above given, is applicable alike to all the swell-boxes that may be introduced in an Organ, the third rule directs that the area devoted to the shutters or louvres should vary in accordance with the nature and offices of the several divisions of the instrument.

In the First or Great Organ, only a section of the speaking stops should be inclosed; and the swell-box should have the largest area possible shuttered, so that when the box is fully open there should, beyond a slight refining effect on the tone, be no practical loss of power. Accordingly, when the position of the Great Organ permits, both the front and the ends of its swell-box should be shuttered to as large an extent as proper construction will admit of.

In the case of the Second or Choir Organ, we do not consider that a larger area than that presented by the front of its swell-box, when properly proportioned, is necessary to be shuttered, especially as the box is likely to be wide and high in proportion to its depth. When the Choir division is placed in the same swell-box with the expressive section of the Great Organ, it must accept the conditions imposed by the latter. It will, however, not greatly suffer, if it suffers at all, by those conditions.

In the Third or Swell Organ full powers of expression are absolutely essential; and these can be secured in the case of a properly-constructed swell-box, of ample dimensions, by having its front entirely devoted to shutter-work, reaching from the level of the internal rack-boards to its roof.

For the swell-box of the Fourth or Solo Organ, the treatment just recommended for that of the Swell division may, under all ordinary circumstances, be adopted: but in Concert-room Organs of the first magnitude, the swell-box may with advantage have a greater shuttered area, so that the reed stops on wind of high pressure, which the Solo division may contain, can at the performer's will speak as freely as fully-exposed stops. In the case of an important and properly-placed Solo Organ, we strongly recommend that its swell-box be shuttered in front and back, and that its balanced expression-lever be given a compound action, operating on the back shutters only during the first half of its movement, and on both the back and front shutters during the remaining part of its movement; completely opening all the shutters at the limit of its movement. The result of such an action would be a very gradual and magnificent *crescendo*, with a corresponding *diminuendo*. This treatment can, of course, be applied to any other division.

The swell-chamber containing the expressive section of the Pedal Organ should have the maximum amount of shutter area, so that there may be no objectionable confinement of sound.

We now come to the consideration of certain details of construction, and may properly commence with those connected with the plain walls and roof of the swell-box. In the construction of these portions, beyond their proper thickness, the chief matter to be attended to is perfect solidity throughout, so that there may be no possibility of jarring or false vibration being set up in them while the larger inclosed pipes are speaking, or any lessening of their efficiency by the contraction of their component parts and the accompanying opening of joints. It is essential that only wood of the best quality, perfectly seasoned and dry, be used; otherwise imperfections are certain to show themselves when the work is subjected to the shrinking action of dry air for a length of time. Several modes of construction may be followed according to the dimensions of the box. Perhaps the most suitable, under general conditions, is that known as framed and flush paneled work. In this class of construction it is only necessary to have the framing securely mortised and tenoned, glued, and wedged; and the flush panels, of the same thickness as the framework, tongued into the frames and well glued in the manner indicated in the Section A, Fig. CCCLXV.; or rebated, leathered and firmly screwed to the

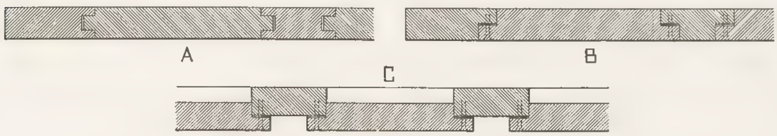


Fig. CCCLXV.

frames, as indicated in Section B. Instead of rebating both the frames and the panels, the latter alone may be rebated, leathered, and screwed to the frames, in the manner indicated in Section C. This last method is quite satisfactory constructionally, but as it presents an uneven surface inside the swell-box, it interferes somewhat with the reflecting property of the walls.

In constructing the walls of the swell-box, provision must be made for easy access to the interior for tuning. A door about eighteen inches wide and about five feet high will be convenient. It must be of the same thickness as the wall of the box in which it is located, and be leathered or felted so as to prevent any vibration while the pipes are speaking. It should be secured by a lock and several turn-buttons, so as to hold it rigid in every part. When the swell-box is very large and is conveniently situated, entrance may be made through a trap-door formed in the floor of a passageway.

When the swell-box becomes a prominent feature in the external design of an Organ, it should receive some ornamental treatment. This may be given, when any plain construction, as above described, is adopted, by appropriate decorative painting; or it may be accomplished by giving the framed and paneled construc-

tion, on all exposed sides, an ornamental finish. Under ordinary circumstances the addition of a molded cornice, with or without an ornamental cresting, will be sufficient. It is very seldom that any more than the upper part of a swell-box is seen from the front.

Although the top of the swell-box is generally flat and laid horizontally, there may be occasions when it will be advisable or necessary to place it on an incline. The impression, which seems to have obtained in certain quarters, that the closer the top is to the inclosed pipe-work the better will be the acoustical properties of the swell, has led to the occasional adoption of a form of top which follows to a pronounced extent the pyramidal disposition of the pipes, the longest of which occupy the central portion of the box. This practice, founded on a misconception of the acoustical problem involved, should never be followed. If any inclination is to be given to the top, let it be such as will add to the height of the front or shuttered side of the box, and will aid in reflecting the sound in an outward direction, instead of throwing it back on the pipe-work from which it emanated. Much may be done by a scientific treatment and disposition of the top of the swell-box to improve its acoustical properties ; and this matter deserves the attention of all interested in scientific and artistic organ-building.

The entire internal surface of the walls, top, etc., of the swell-box should either be painted with three coats of white-lead and linseed-oil paint and finished with hard enamel, or sized and varnished with three coats of best hard-drying floor varnish. By such means the wood is not only protected from the action of the atmosphere in all weathers, but it is given a hard and glossy reflecting surface, which materially aids the clearness and brilliance of the tones of the inclosed pipes. The exterior of the swell-box should also be protected by coats of oil paint or oil varnish. Thin coats of shellac varnish should never be depended on in a variable climate.

We have now to consider the mechanical portion of the swell-box, by means of which expression and flexibility are imparted to the inclosed tonal forces. This portion consists of a series of shutters or louvres, carefully fitted to each other and to the opening in the box, and supported on metal pins or centers so as to turn with the greatest freedom and without vibration. In old Organs, and also in modern ones in which the old-fashioned "hitch-down" or recovering "swell-pedal" is used, the shutters are hung horizontally; but in all properly-appointed instruments in which the balanced expression-lever is introduced, the shutters are supported vertically. It seems unnecessary to remark that in Organs of any pretensions toward completeness no other form of expression-lever should be used. Horizontal shutters belong to the past; and the recovering pedal, with its more or less awkward hitch-down or fixing arrangements, should be placed, for good and all, among the curiosities of organ-building. Strange to relate, there are organists to-day who prefer this old-fashioned and obviously insufficient appliance; and these are the men who wax eloquent against the extension of the swell in the Organ.

The shutters should be made of the finest and the lightest, straight-grained white pine that money can procure. Every precaution must be taken to prevent shrinking and twisting. The practice followed by the late Messrs. Roosevelt is

strongly to be recommended. The vertical shutters of their fine swell-boxes were formed of several longitudinal pieces of clean white pine glued together in the manner indicated in the accompanying Transverse Section of a shutter, Fig. CCCLXVI. Shutters should be of the same thickness as the walls of the swell-box, when the latter are constructed as above described; and under no circumstances should they exceed two inches in thickness. The edges of the shutters which close together may be formed in three different ways. Two of these are shown in the Transverse Sections A and B, Fig. CCCLXVII. The form shown at A is that which has been almost invariably adopted for horizontal shutters, and very generally for vertical ones. There are, perhaps, no serious objections to be advanced against its use providing the edges are accurately adjusted and thickly felted. The form shown at B is, however, to be preferred, requiring less felted surface,

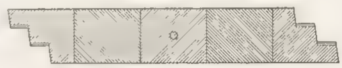


Fig. CCCLXVI.

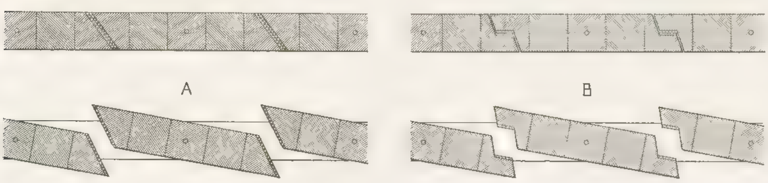


Fig. CCCLXVII.

and furnishing a closer and freer joint. A third form is shown in the Transverse Section of the Roosevelt shutter, Fig. CCCLXVI. Two layers of felt should be used in all cases: one being glued and tacked to each surface, so that felt may strike felt when the shutters close. The unfelted edges must be fitted as closely as practicable, but under no conditions must they touch or bind. The length of the shutters should be about ⅛ inch less than the opening of the frame in which they are pivoted. When the shutters are hung horizontally, thin metal washers must be placed on their pivots to prevent their ends coming in contact with the sides of the frame. Vertical shutters must be pivoted so as to turn without any apparent friction. Their lower pivots should be in the form of conical steel points, resting in corresponding sinkings in bell-metal plates. The upper pivots may be plain steel pins working in hardwood, well black-leaded.

Of equal importance to the proper fitting and pivoting of the shutters is the careful construction of the action which links all the shutters together for the purpose of opening and closing them. Here, again, every expedient must be resorted to to eliminate all avoidable friction, and to prevent any binding or strain in the moving parts. It is imperative that absolute uniformity and smoothness obtain throughout the movements of opening and closing the shutters; otherwise, it would be impossible for the performer to properly control the swell. A stiff, uneven or jerky swell action is an abomination, and, unfortunately, it is by no

means uncommon. The action, in its usual form, is extremely simple. It consists of a series of small arms projecting obliquely from the ends of the shutters, linked together by a rod moved by the expression-lever under the foot of the performer. This action is, in part, shown in Fig. CCCLXVIII. The shutters are indicated at A, the projecting arms at B, and the rod linking the arms together at C. Steel pins, firmly driven into the rod, pass through holes in the arms, in the manner indicated, and with as little friction as possible. When there is any likelihood of

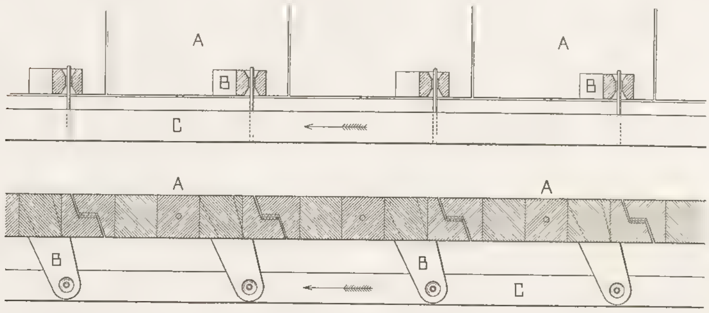


Fig. CCCLXVIII.

the action binding through any inequality in the fitting of the arms, all the arms between the two end ones should have slots instead of circular holes for the reception of the steel pins. The end pins are usually tapped on their upper ends, which project above the shutter arms, and are there furnished with washers and nuts for the purpose of supporting the rod. The simple mechanical arrangement just described, which is applicable to both vertical and horizontal shutters, has the effect of opening and closing all the shutters simultaneously. It is very desirable that the lever or cam action, which moves the linking rod, should be so devised as to open the shutters slightly at first, and then with a gradually-increasing motion, while the movement of the expression-lever, under the pressure of the foot, may be perfectly uniform. This class of action can be devised by any one versed in mechanics. Devices of a somewhat complicated character have been proposed for the purpose of securing a gradually increasing *crescendo* and a corresponding *diminuendo*, but none of these have ever come into general use.

In the case of a small box of moderate dimensions, in which the pipe-work is closely planted, and which has accurately-fitted shutters, it is desirable to provide a small trunk or conveyance from it to some adjoining room, or space above the ceiling of the organ-chamber, to enable the air from the speaking pipes to pass away without in any way altering the ordinary condition of the air within the box while the shutters are closed. Probably the expedients just spoken of will be considered by the average organ builder of to-day unnecessary refinements.

CHAPTER XLIII.

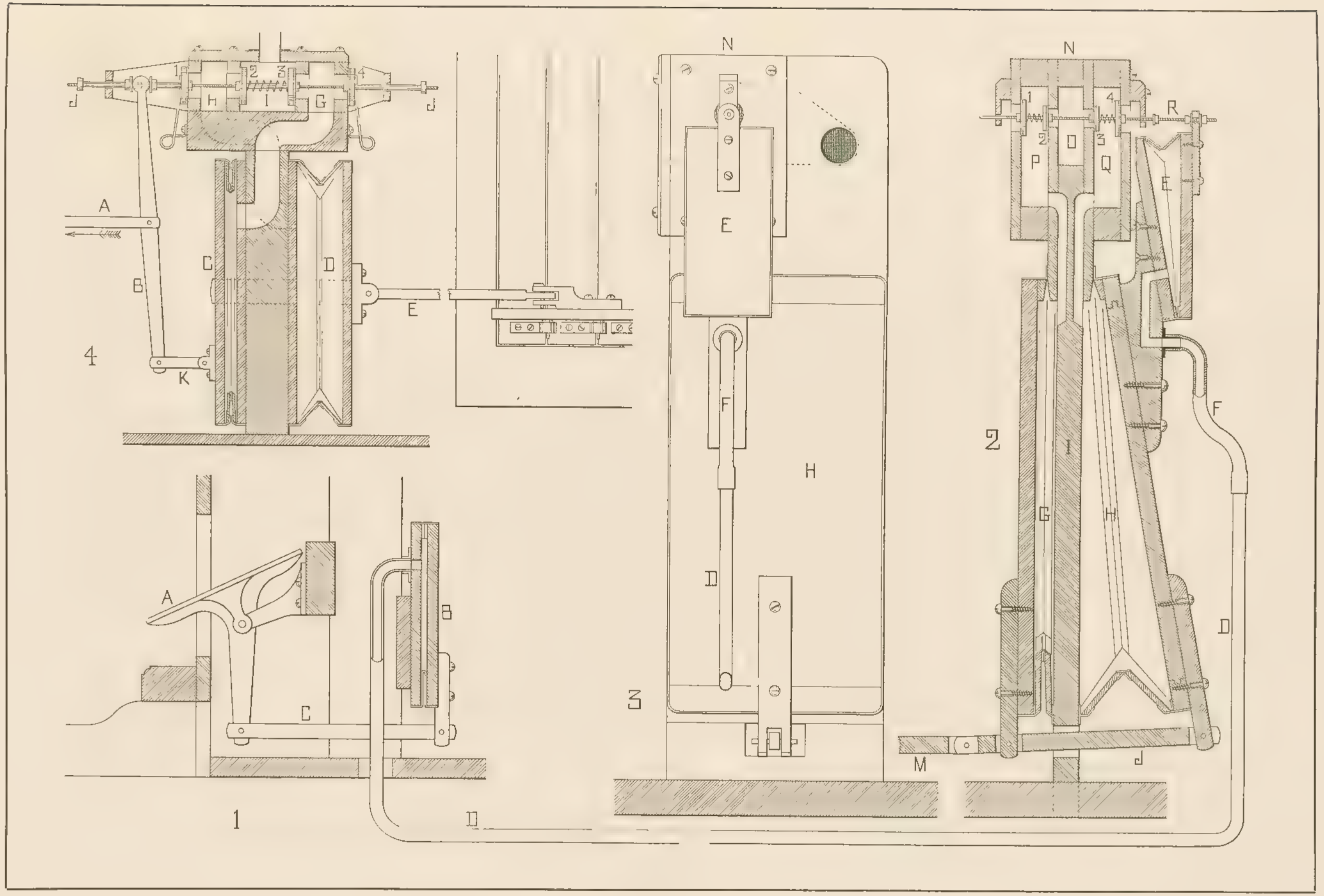
THE EXPRESSION-LEVER.

THE Expression-lever, or, as it has been commonly called by English organ builders, the Swell-pedal, is the appliance controlled by the foot of the performer, whereby the shutters or louvres of the swell-box are opened and closed. Two forms of expression-levers have been introduced, namely, the *recovering* or "*hitch-down*" *lever* and the *balanced lever*. The former has until recently been used invariably by English builders in their favorite single-swell Organs. It operates in every case horizontal shutters, which close by the action of a spring or weight. By this action the swell-pedal is recovered or returned to the inoperative position. When this pedal is depressed by the foot the shutters are opened; and when the pressure of the foot is relaxed the pedal rises under the influence of the spring or weight and the shutters close. As it was found necessary immediately after the introduction of the louvred swell-box that means be provided for fixing the louvres more or less open when required, notches were cut either in the vertical slot in which the pedal moved up and down, or in a rod which hung, at a slight angle, against the right-hand or farther edge of the pedal. In the former case the pedal was hitched into the notches by a slight lateral motion controlled by the foot, while in the latter case the notched rod was permitted by the foot to catch and hold the pedal at set stages of its motion. The pedal was released by a slight lateral pressure of the foot (against the rod) while depressing it. These primitive methods have been superseded by different forms of automatic mechanical catches, which, while they do not interfere with the free motion of the pedal so long as the foot presses it, fix the pedal in any position at which the foot leaves it. Probably the most satisfactory of these automatic catches is that invented and patented by Mr. Richard Smith, Organ Builder, of Glasgow, Scotland.* Pedals or levers of a

* "Improvements in and relating to Organs and such like Key-board Wind Instruments." English Letters Patent, No. 9562, dated July 6, 1887.

compound form have been introduced, which become free the instant the foot of the performer presses them, and which remain stationary at any point at which the foot leaves them. One of the best of these compound pedals is that invented by Messrs. Wilkinson & Son, Organ Builders, of Kendal, England. It is unnecessary to enlarge on this subject, for it is full time that the hitch-down pedal be placed among the antiquated curiosities of organ-building, notwithstanding the fact that there are many good old-fashioned organists whose feet cling lovingly to it still.

The balanced expression-lever was first introduced by French builders, and has continued to be systematically used by them since its inception. This lever consists, in its most practical form, of a flat metal plate, convenient to the foot, and pivoted behind so as to rock on its center. A lever-arm projecting from the back of the plate is connected with the mechanism which moves the shutters of the swell-box. The balanced lever is most efficient in its control of the swell shutters, and, accordingly, of the *crescendo* and *diminuendo* effects, when it is associated with a direct mechanical action. With such an action, every motion of the foot on the lever is faithfully conveyed to the swell shutters. This can hardly be claimed for the most ingenious pneumatic or electro-pneumatic actions. Wherever it is practicable the simple mechanical action should be used, every care and expedient being taken and adopted to eliminate unnecessary friction and to balance the whole action perfectly. In the case of a large Organ, in which the area of the swell shutters is correspondingly large, it is desirable to adopt some method to lighten the movement of the balanced lever. This has been accomplished with considerable success by the introduction of a pneumatic appliance between the balanced lever and the shutter movement. Several forms of such an appliance have been invented by American organ builders, one of which has been patented by Mr. Ernest M. Skinner, of Boston, Mass. All the more efficient forms have, however, been constructed on the principle set forth in the tubular-pneumatic appliance introduced in the Organs built by the late Messrs. Roosevelt, of New York. This may be described, with the aid of the drawings given in Plate XI., as follows: In Fig. 1 are shown the balanced expression-lever and its attendant pneumatic action. A is the expression-lever, linked to the small bellows or primary motor B by the rod C in the direct manner indicated. Communicating with the interior of the motor is the tube D, which extends thence to the secondary motor of the pneumatic lever which actuates the shutters of the swell-box. Fig. 2 is a Longitudinal Section of the pneumatic lever. E is the secondary motor connected with the primary motor B by the metal tube D and the flexible india-rubber tube F. So connected, it is obvious that when the primary motor B is collapsed by the action of the expression-lever, the secondary motor E is expanded by the air transmitted through the tube D, and vice versa. G and H are the two cuneiform bellows, hinged to the central board I, and linked together by the rod J. These form the pneumatic lever which actuates the shutters of the swell-box through any convenient mechanism connected with the trace M. In the head or valve-box N are three chambers, which communicate with each other and with the external air through the circular openings pierced in their walls as indicated. Two pairs of disc-valves close all these openings when the appliance is at rest, the valves being


1
2
3
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A
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C
D
E
F
G
H
I
J
K
M
N
O
P
Q
R

held against their respective openings by means of the spiral springs as shown. All the disc-valves are carried on, but not tightly fixed to, the valve-stem R, which is moved by the arm of the secondary motor E. The central chamber O is constantly charged with compressed air while the Organ is in use. The chamber P communicates, through a duct, with the bellows G, while in like manner the chamber Q communicates with the interior of the bellows H. Fig 3 is a Side View of the appliance: the several parts being indicated by the same letters they bear in the Longitudinal Section.

The operation of the appliance is simple and, with certain limitations, efficient. The positions of all the movable parts in Figs. 1 and 2 indicate that the shutters of the associated swell-box are open to their full extent. Now, when the foot of the performer depresses the front end of the expression-lever at A, the primary motor B is expanded to a corresponding extent, the exact contrary movement taking place at the same instant in the secondary motor E. The arm of this latter motor pushes the valve-stem R inward, moving the disc-valve 4 from its seat, and placing the chamber Q in communication with the open air, at the same time moving the disc-valve 2 from its seat, and placing the compressed-air chamber O in communication with the lateral chamber P and, accordingly, with the interior of the bellows G. The compressed air immediately inflates the bellows G, which collapses to the same degree the linked bellows H. The latter, in collapsing, moves the secondary motor E outward sufficiently to return the disc-valves 2 and 4 to the closed positions shown in the Section, and so arrest any further movement of the appliance until a further motion is imparted to the expression-lever by the foot of the performer. It is quite obvious that as the secondary motor E is attached to the movable board of the bellows H, it will follow, in the contrary direction, the motion of the bellows, "hunting" the series of disc-valves, and causing the appliance to reproduce automatically the motion of the expression-lever, whatever it may be, and no more. Though somewhat difficult to describe, this ingenious compound action can be easily traced and understood by any one conversant with pneumatic appliances as found in organ-work.

Another pneumatic lever for actuating the shutters of the swell-box has been patented by Mr. Ernest M. Skinner.* This appliance is constructed on the same principle as the one above described, but is much simpler in form, primary and secondary pneumatics being omitted along with a tubular connection. A simple mechanical movement is established between the expression-lever and the valves of the pneumatic lever. In Fig. 4 is given a Longitudinal Section of this appliance. It will be understood, although not shown, that the trace A is connected by means of any convenient mechanical action with the balanced expression-lever operated by the foot of the performer. All this trace has to do is to move the lever B a short distance forward and backward. C and D are two parallel bellows linked by side bars so as to move together. These form the pneumatic lever which actuates the shutters of the associated swell-box. The trace E is connected with the shutter action. In the valve-box F are the three chambers G, H, and I,

* "Swell-pedal Action for Pipe-Organs." United States Letters Patent, No. 500,040, dated June 20, 1893.

which communicate with each other and the external air through the four circular openings in their walls, as indicated. The four disc-valves 1, 2, 3, and 4 close all these openings in the manner shown, when the appliance is at rest. All the disc-valves are carried on, but not fixed to, the valve-stem J, which is moved by the lever B. The central chamber I is constantly charged with compressed air while the Organ is in use. The lateral chamber G communicates, through a duct, with the interior of the bellows C, while, in like manner, the chamber H communicates with the bellows D. The disc-valves 1 and 4 are pressed against the exhaust-openings by external wire springs, while the valves 2 and 3 are pressed against the supply-openings by the spiral spring between them, as indicated.

The operation of this appliance is in all essentials similar to that previously described. Here the lever B fulfils the office performed by the secondary motor in the Roosevelt appliance. While the lever B, which has its fulcrum in the end of the link K attached to the bellows C, is first moved by the trace A, drawing or pushing both a supply- and an exhaust-valve from their respective seats, it is immediately restored to an inoperative position, hunting the valves, by the movement of the bellows C, which carries the fulcrum link K. The to-and-fro motions of the bellows C and D are responsive to the motions of the expression-lever under the foot of the performer. So long as the expression-lever is moved, the bellows will have a corresponding movement; and the instant the foot ceases to move it, the bellows are arrested by the closing of the hunted valves, which stop both supply and exhaust.

In the early part of the present Chapter we remark that the most practical form of the balanced expression-lever is a flat metal plate convenient to the foot. Now, as this form has not been generally adopted by American organ builders, and is by no means imperative in Organs which have only one expressive division, we may add a few words in support of our contention. When there are two or more balanced expression-levers introduced, commanding different divisions of the Organ, these must be of such a form and be placed close together to render the shifting of the foot from one to the other, and the operating of two simultaneously, matters of perfect ease. This can only be properly and conveniently accomplished by having the expression-levers perfectly flat on the surface on which the foot rests, and only sufficiently broad to render it easy to actuate any one without touching the adjoining ones. When levers are shaped to receive the heel of a shoe, and are curved so as to meet the form of the sole, there will always be some difficulty in quickly changing the foot, and of catching and bringing into uniform motion two contiguous levers. It is not unusual in American Organs to see the balanced expression-lever tastefully designed in strict accordance with the form of a shoe; and there is no serious objection to such a treatment when *only one* lever is required. The French builders have wisely adhered, so far as our observation extends, to the perfectly flat balanced lever. Further remarks on the expression-lever will be found in the Chapters on the Church, Concert-room, and Chamber Organs.

CHAPTER XLIV.

THE ANEMOMETER.

THE appliance or instrument which in common organ parlance is known as the Anemometer, and which with greater accuracy may be designated by the term Manometer, is employed to measure the pressure of the wind supplied by the bellows to the pipe-work of the Organ. In its simplest form the anemometer consists of a glass tube bent after the fashion of an S, placed on its side, and having its lower bend filled to a convenient extent with water. When compressed air—the organ-wind—is conveyed into the lower open end of the tube, it presses on the surface of the water in the bend, driving it downward there and, necessarily, upward in the adjoining vertical limb. When the water is at rest, the distance between its lower and upper surfaces indicates the pressure of the wind, measured in inches.

Several forms of anemometers have been introduced by different makers, but, for ordinary and reasonable pressures, all have been constructed on the same principle. The form illustrated in Fig. CCCLXIX., on the following page, is a very convenient one for all-round use, and one that can be carried about without much risk of injury. It consists of the oblong box of hardwood A, about 10 or 12 inches long, 4 inches wide, and $\frac{7}{8}$ inch deep internally, which is fixed upright on the weighted stand B. Within the box are the two parallel glass tubes C and D, about $\frac{9}{16}$ inch in diameter, placed $\frac{7}{8}$ inch apart. These tubes are cemented in the metal junction E, which is strapped tightly to the box as indicated. The top of the longer tube passes through a hole in the top of the box, where it is protected by the metal band F. The upper end of the other tube is cemented into the metal elbow G, the horizontal arm of which passes through the adjoining side of the box to receive the end of the india-rubber tube H. Between the glass tubes is placed the sliding boxwood scale K, divided into inches and eighths as shown. This scale passes through the top of the box at I, and slides in a dove-tail rail behind, so as to be easily moved up and down. The india-rubber tube is attached to the ordinary pipe-foot J, and may be made any convenient length.

When the anemometer is to be used, water is poured into the open end of the tube at F, until it rises in both tubes to about the height indicated. The pipe-foot J is placed over a convenient hole in the upper-board of the wind-chest (a pipe being removed for the purpose) and the corresponding pallet or valve is opened, and the organ-wind to be measured is allowed to enter the instrument. The water in the tube D is instantly pressed down, while a corresponding rise takes place in the tube C. When the water becomes stationary, the scale K is drawn up until its bottom line with the arrow-head is level with the surface of the water in the tube D: then, the line of the scale which is level with the surface of the water in the tube C gives the pressure of the wind in inches and fractions. Anemometers of the form just described can be easily constructed to measure wind-pressures up to 30 inches. An instrument for measuring high pressures may be formed of a single glass tube, the lower end of which is inserted deeply in a metal reservoir filled with water. The wind is conveyed into the upper portion of the reservoir, where it presses on the water and drives it upward into the glass tube. The height of the column in the tube above the surface of the water remaining in the reservoir determines the pressure of the wind. The reservoir must have a strip of glass inserted in its side to enable the level of the water within to be seen.

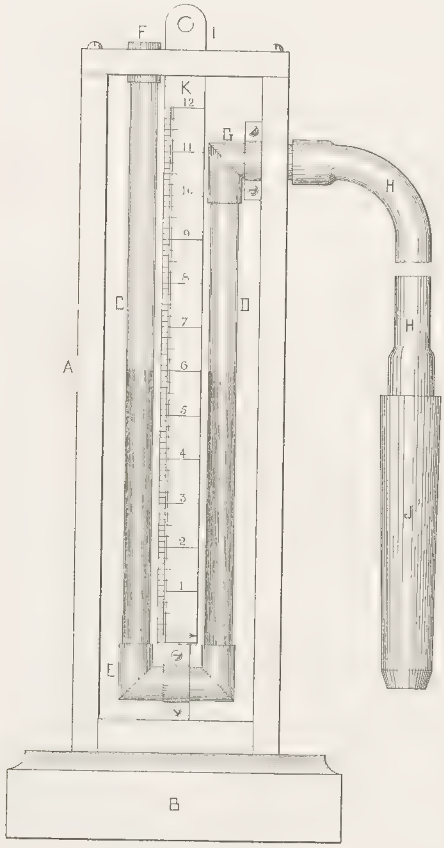


Fig. CCCLXIX.

It is most desirable that when the wind-pressures of the several divisions of an Organ have been permanently determined, each pressure should be indelibly recorded on some visible spot of the division to which it refers. By this precaution all danger of the pressures being forgotten is prevented, and any alteration through interference with, or accident to, the bellows or reservoirs can be detected at any time. The slightest alteration in the wind of a division will very seriously interfere with the correct speech and pitch of its pipe-work.

CHAPTER XLV.

THE BELLOWS AND ITS ACCESSORIES.

THE Bellows have not inaptly been called the lungs of the Organ: and as in the human body it is essential for health that the lungs be in perfect condition, so in the Organ it is necessary for its efficiency that its lungs be capacious, sound, and otherwise in good working order.

Care must be taken to provide in every Organ sufficiently large and properly-constructed bellows; and if any miscalculation is at all likely to occur, most certainly let it be on the safe side, for too large a supply of wind, provided it is uniform and steady, is a complaint no Organ can suffer from. On the other hand, a short supply, invariably attended by unsteadiness, is a most serious defect, causing the Organ to be asthmatical and absolutely untrustworthy. Small bellows cost less to make than large ones; accordingly, in close-estimated or low-priced work there is a strong temptation for the organ builder to curtail their dimensions. It not unfrequently happens that the bellows get reduced too much, to the great injury of the tonal powers of the instruments in which they are placed. A common excuse for small bellows is that the space provided for the Organ is too confined to allow of the insertion of one of adequate dimensions. Owing to the blunders of architects, in some cases this excuse may have a reasonable foundation, but there are very few cases in which the ingenuity of the well-paid organ builder cannot overcome the difficulty. When both area and height are very limited every expedient must be resorted to, to render the bellows as efficient as possible. If the bellows has to be placed inside the Organ, the dimensions of the receiver will, of course, be dictated within certain hard and fast limits of measurement; and when the available space is too small for the reception of a bellows of the ordinary compound construction, the organ builder must provide feeders of such a nature as will inject a copious and steady stream of wind into the receiver, or avail himself of one or

other of the mechanical blowers which are now at his command. It must be understood that a copious, continuous, and steady supply of wind to an Organ depends chiefly upon the nature and efficient operation of the feeders or blower, and not upon the dimensions of the receiver or reservoirs. The receiver is simply a primary storage chamber in which the organ-wind is weighted or has the required degree of compression imparted to it. The supply of wind depends entirely upon the feeders or blower.

Two forms of bellows have been used in modern organ-construction, although only one remains in favor at the present time. The first form is known as the simple or diagonal bellows. It is called *simple* because it consists of only one chamber, which acts both as feeder and receiver or reservoir, while it derives the name *diagonal* from the manner in which it expands. When inflated this bellows is in the form of a wedge, and from this fact has sometimes been designated the cuneiform or wedge bellows. The second form is termed the compound or horizontal bellows. The term *compound* is given because the bellows consists of two principal portions: one of which collects and injects the wind into the other portion, where it is stored and has the required degree of compression imparted to it. The term *horizontal* is derived from the horizontal action of the receiver, or the portion in which the wind is stored.

In modern organ-construction bellows are employed for two purposes; namely, for furnishing a supply of wind at a required pressure; and, on the other hand, for creating a vacuum as complete as is practicable under the conditions which obtain in the Organ. The former is termed the pressure bellows, and, in either its simple or compound form, is employed to sound the pipe-work, and also to assist certain mechanical movements. The latter is called the exhaust or vacuum bellows; and has been employed exclusively in the mechanical department of the Organ.

The old diagonal bellows was used in all the early Portative and Positive Organs, as shown in Figs. XI. and XIII. and other illustrations given in Chapter I. It continued to be used, chiefly by German builders, until a comparatively recent period. For instance, the large Organ built in 1862 by Edmund Schulze, of Paulinzelle, for the Parish Church of Doncaster, England, was furnished with twelve large diagonal bellows.* A very brief description of the diagonal bellows will suffice here, for this primitive appliance has now taken its place among the curiosities of organ-building.†

* Prior to the year 1894 the blowing arrangement remained as it was put in by Schulze, but in that year the Organ was partly reconstructed, and a mechanical blowing apparatus was supplied and properly connected with the series of diagonal bellows, which, accordingly, now serve as receivers or reservoirs in which the wind is stored. The blowing apparatus, worked by a 2½ H. P. gas engine, is located in a room about forty yards distant from the Organ, the air being drawn from the organ-chamber and forced back, through tubes running underground, into the series of reservoirs in the Organ.

† We may refer readers who desire to learn more respecting the appliance, to the pages of "L'Art du Facteur d'Orgues," by Dom Bedos; "Nouveau Manuel Complet du Facteur d'Orgues" (Paris 1903); and "The Organ," by Hopkins and Rimbault. In the last work a considerable space has been devoted to the description of the diagonal bellows. We may, however, point out that the contents of paragraph 43 have to be seriously questioned. In a proper comparison between the simple and the compound bellows, it must be strictly borne in mind that the receiver or reservoir must not be considered in the calculation of the

The diagonal bellows is constructed on the same principle as the ordinary hand bellows; that is, it consists of two boards, hinged together at one end, and furnished with jointed ribs on the sides and free end. It is inflated or charged with air by raising its movable or top-board until the ribs are properly expanded, the air being admitted through valves formed in the stationary or bottom-board. A valved opening is provided in the bottom-board near to the hinge end, through which the compressed air from the interior of the bellows finds its way into a trunk or conduit fixed underneath, and thence into the several divisions of the Organ. On the movable board is placed a weight to impart the necessary pressure to the wind before it enters the wind-trunk on its way to the wind-chests. The bellows is filled with air by the movable board being raised by any simple mechanical action. Whenever the action is released, the wind is compressed and delivered as above described.*

The compound bellows was invented about the year 1762 by an English clock-maker of the name of Cumming. It was put to practical test for the first time in an Organ constructed for the Earl of Bute in 1787. It subsequently came into general use in Great Britain. The compound bellows comprises two chief portions—the feeder or feeders and the receiver.† The feeders collect the air and inject it into the receiver, where it is compressed to the required degree under the action of weights or springs. It passes thence either directly, through wind-trunks, to the wind-chests, or is distributed to the intermediate reservoirs.

The receiver may be first described. It consists of two principal parts: one of which is stationary and the other movable. The latter part is now almost invariably constructed after one approved model; but the stationary part is made in different ways dictated by circumstances of locality, available space, and certain practical considerations. We select the most convenient and generally-approved form for description and illustration. This is commonly known as the box- or band-receiver, because its lower or stationary part is in the form of a shallow box, or because its bottom is surrounded by a vertical band, called the trunk-band, to which are attached the wind-trunks that convey the compressed air from the

wind *supply;* its true office is not connected with the *amount* of wind supplied, but with the *quality* of it. The feeders alone control the *supply*. The simple or diagonal bellows deals with both *supply* and *quality*, being both feeder and reservoir in one.

* In ancient Organs a large number of diagonal bellows appear to have been introduced, but these were probably of small size and very simple construction. We are told by Wulston the Deacon (died A. D. 963) that the Organ in the Monastic Church of Winchester had no fewer than twenty-six "pair of bellows." The Organ in the Cathedral of Magdeburg had twenty-four bellows, and that in the Cathedral of Halberstadt had twenty. From an engraving in Prætorius' "Theatrum Instrumentorum," published in 1620, we gather that the bellows then in use were not weighted; but that the necessary pressure was imparted by the exertions of the blowers. Each of the eighteen bellows shown in the engraving has a sort of shoe fixed on the free end of its movable board. The blowers are represented hanging by their hands to high horizontal bars. Each man is apparently raising one bellows with one leg, while he collapses and imparts pressure to another adjoining bellows with his other leg. How this could have been satisfactorily accomplished is not very clear.

† Both the names *receiver* and *reservoir* are used to designate this portion of the compound bellows; but as its function is more clearly defined by the former term we shall adopt it in our subsequent remarks. The term *reservoir* is properly used to designate an auxiliary chamber fed with wind from the receiver, and in which wind is stored under special pressure for any division of the Organ. Although there may be only one receiver, there may be several reservoirs. In small Organs the receiver has no auxiliary reservoir.

receiver to the wind-chests, etc. The bottom of the receiver consists of a strong framework, either filled with flush panels, or with its openings covered on its upper side with strong boards, edged with soft leather, and tightly screwed down on the framing. This framed and paneled bottom is called the middle-board when introduced in the complete compound bellows, because it occupies a position between the chambers of the feeders and the receiver. The thickness of the frame will, of course, vary with its superficial dimensions and the weight it has to carry. Perfect rigidity must be secured to resist the action of the attached feeders. For receivers of moderate size, pine 1½ inches thick will be sufficient, while for large receivers wood not less than 2 inches thick should be used. The different members of the framework must be of sufficient width to give the necessary strength, and be put together in the strongest manner. When filled in with flush panels, all the joints must be covered with strips of leather. Instead of flush panels, movable boards, edged with soft leather, and tightly screwed down over the openings of the framework, are to be recommended; for not only will they carry the valves that are between the feeders and the receiver, and which may require renewal or repairs; but, by their easy removal, they will expose the valves on the inside of the feeders for inspection or repairs when necessary. In Fig. I., Plate XII., is given a Top View of the middle-board as above described: one half showing the movable panels, pierced for valves, and the other half showing the simple framework. The trunk-band of the receiver is formed of four pieces of clear white pine, equal in length to the sides and ends of the middle-board, and of sufficient width to receive the flanged ends of the wind-trunks. Its thickness may vary from 1 inch to 2 inches according to the size of the receiver. The band must be dovetailed and glued together at its angles, and securely glued and screwed to the upper surface of the middle-board. The band, apart from its office in connection with the wind-trunks, is invaluable in imparting great strength and rigidity to the entire bellows; such being the case, it should never be dispensed with when there is height sufficient for its introduction. It must be understood, however, that the trunk-band, whatever its height may be, has no effect on the wind-supply or the storage-capacity of the receiver. When the trunk-band has been attached to the middle-board, all the internal angles should be covered with leather, well glued: these will prevent any leakage, should the joints open from any cause. The next process in the construction of the receiver is to form the perforations in the panels of the middle-board for the reception of the valves. Several forms of these perforations with their corresponding valves have been introduced by organ builders, but only very few have stood the test of time. The earliest form, which obtained in the time of the diagonal bellows, was simply an oblong opening covered with a wooden pallet faced and hinged with thick, soft leather. This style of valve was improved by using a light frame of wood, over which the leather was stretched, thereby securing a more silent action. Shortly after the introduction of the compound bellows a great improvement took place in the formation of both the perforations and valves, all woodwork being abandoned in the latter in favor of thick, pliable leather. One of the simplest forms, held in considerable estimation about half a century ago by English builders, is that known as the "frog-valve." The

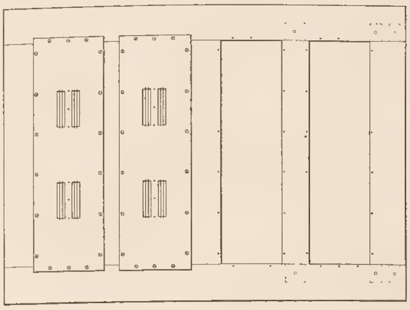


FIG. I.

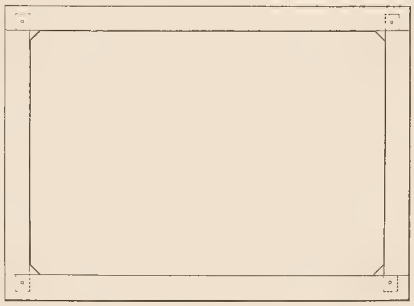


FIG. V.

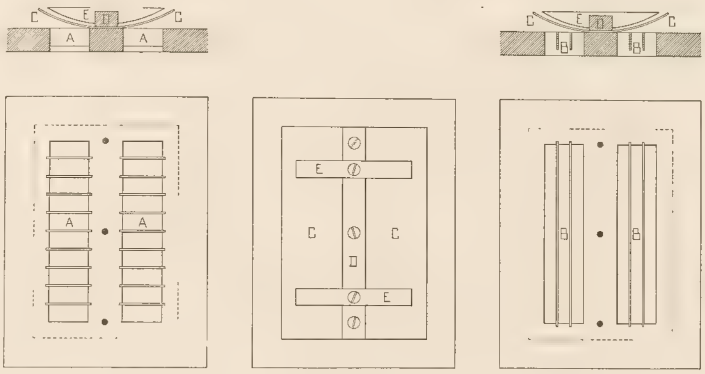


FIG. II.

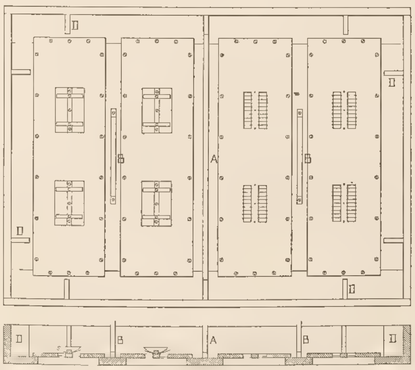


FIG. III.

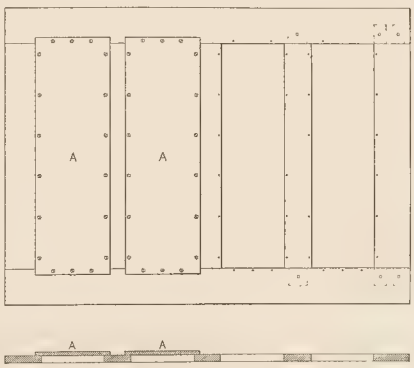


FIG. IV.

openings of this valve are circular holes, from 1 inch to 1½ inches in diameter, bored close together in groups of six or more. These holes are cleanly bored from the upper or valve face, and have their rough under edges burnt smooth with a conical iron. The valve is a single piece of thick pallet-leather or soft and pliable tanned skin, cut so as to amply cover the series of holes, and held in position by four pieces of strong linen tape stitched to its corners. The other ends of the tapes are folded and glued, and fixed down to the surface of the panel with large flat-headed tacks and metal washers. The valve is stretched sufficiently by the four tapes radiating from it to keep it in its place over the holes, but not so as to prevent its rising for the free passage of air from the feeders. A modification of this valve is formed of a disc of leather, secured in its center, and covering five or six holes disposed in circular fashion around the central point. To prevent the disc rising too high or becoming crippled in any way by the action of the wind, a turned piece of wood, slightly conical on its lower face, and somewhat less in diameter than the leather disc, is screwed down on the center of the disc, holding the valve firmly in position.

The most approved form of bellows-valve, now used in better-class work, consists of an oblong piece of soft and pliable tanned sheepskin, hinged along one of its longer edges, and lying over an oblong opening cut through the middle-board, or through a panel secured to the same. This opening is bridged at intervals, longitudinally or transversely, by thin strips of hardwood, inserted edgewise, to prevent the leather valve being sucked or pressed through the same. In some cases, instead of the long, bridged opening, two rows of holes are bored as close together as practicable, the number and size of the holes being commensurate with the requirements. Valves of the class just described are frequently and properly arranged in pairs, having a single piece of leather of sufficient size to cover two oblong openings or series of holes, secured in position on the valve-seat by a bar of wood screwed down along its center. The valve in its most approved forms is shown in the Top Views and Transverse Sections given in Fig. II., Plate XII. The oblong openings bridged transversely are indicated at A in the left-hand Top View and accompanying Section, while similar openings bridged longitudinally are indicated at B in the right-hand Top View and accompanying Section. The length and width of the openings vary according to the size of the receiver and the number of valves introduced. They may be properly made from 1½ inches to 2 inches in width, and from 6 inches to 9 inches in length. The bridging should be about ⅛ inch thick, and dressed level with the surface of the valve-seat. The leather valves are indicated at C, held in position by the hinge-bar D. At E are shown curved pieces of wood required to check the upward throw of the valves. The central drawing is a Top View of the valve and its accessories. Care must be taken, in fitting the valves, not to screw down the hinge-bar D too tightly: it should only bear on the surface of the leather just enough to prevent it rising from its seat there. In addition to this, the holes in the leather through which the screws pass should be punched considerably larger than the size of the screws. When the adjustment is all right, it should be possible to pull the leather valve backward and forward easily, under the hinge-bar, to the extent permitted by the punched

holes. Many valves have been rendered inefficient through being tightly screwed down. In all cases the valve-seats, or the surfaces on which the leather valves rest, must be dressed flat and perfectly smooth, and they should be well rubbed with dry chalk. Perfect pieces of leather of uniform thickness should be selected for the valves; and when cut to the proper shape, they should be rubbed with chalk on their undressed side, and kept pressed between boards until required. Before being secured in their places, their upper or dressed surface should receive a coating of pure, melted tallow. They will ever after lie perfectly flat on their seats. Valves of double leather should never be used. A double valve, as represented in Fig. II., Plate XII., having openings 8 inches long by 1¾ inches wide, bridged in either fashion, is considered sufficient for 500 square inches of feeder area. It is most important to have valves of ample size; for when they are too small or too few in number, the feeders are certain to operate in a sluggish manner and with a very objectionable gasping noise—the lungs are out of order.

For the completion of the stationary part of the receiver nothing further is required save some supports for the ribs and top-board of the upper or movable part. In a receiver of large dimensions it may be desirable to strengthen the construction by inserting one or two transverse bars and screwing them to the bottom frame and the trunk-board. In Fig. III., Plate XII., is given a Top View and Longitudinal Section of the stationary part of a receiver complete in all details, as above described, save with respect to the four valves on the right hand, which are omitted so as to show the bridged valve opening. At A is indicated the position occupied by a strengthening bar, which, if introduced, may with advantage be carried up along part of its length so as to support the center of the top-board of the complete receiver. Two other supports are shown at B, screwed down to the bottom-frame. These supports must be carried up sufficiently high to prevent the heavy top-board bearing down on the closed ribs and straining their leathered joints. At D are pieces projecting inward from the trunk-band, provided for the support of the lower ribs when they are closed. The top edges of these pieces should be covered with thick felt. Such desirable expedients to save the moving parts of the receiver from undue strain cannot be overestimated.

Before proceeding to describe the upper or expanding part of the receiver, a few words may be said respecting its shape in plan. The shape of the receiver, that is, its proportion of width to length, will, as a rule, be decided by the special arrangements of the Organ, especially when it is located within the building-frame of the instrument. When the bellows is placed outside the Organ, its proportions can generally be decided on their own merits. So far as efficiency is concerned, the shape is of little importance so long as it does not necessitate feeders of unsuitable form. For a bellows with two feeders of the ordinary half-drop or hinged type, the best shape ranges between a square and a parallelogram of the proportion of three to four; and when three feeders are adopted, the proportion of width to length should be about two to three or three to five. Three feeders are very desirable, as they prevent any dead-point in the delivery of their wind, but they necessitate the adoption of a three-throw crank or eccentric shaft, properly driven by a motor of some description.

At the point now reached, the box of the receiver may be pronounced complete, unless, when it is of moderate size and is arranged for two feeders of equal dimensions, it is deemed desirable to fit it with equilibrium by-pass valves. These valves considerably lessen the labor of blowing by hand, and prevent the unpleasant sound of escaping wind. They consist of two wooden pallets, faced and hinged with leather, covering openings of adequate size cut through the middle-board—one communicating with each feeder. These pallets are kept closed against any ordinary action of the compressed air by springs. They are furnished with projecting arms from which cords extend to the top-board of the receiver. These cords are so adjusted that when the receiver is fully expanded, both valves are opened simultaneously, allowing the wind from one feeder to pass into the other without adding any to the contents of the receiver, or allowing any to escape into the open air. This arrangement is practicable only when the two feeders are of the same dimensions and rise and fall equally. It is to be recommended for small Church and Chamber Organs to be blown by hand.

The next important portion of the receiver is the top-board, a Top View and Longitudinal Section of which are given in Fig. IV., Plate XII. This board is of the same dimensions as the middle-board, and is similar to it in general construction, as can be seen on comparing Figs. I. and IV., the only difference being that the panels of the top-board are properly solid. In Fig. IV. one-half of the top-board is shown with the applied panels A. These are leathered along their under edges, and are made so as to be easily removed to admit of access to the interior of the receiver for inspection or repairs. The only opening that will be required in the top-board under ordinary conditions, is that necessary for a waste-valve. This opening may be provided by a simple arrangement of the transverse bars of the framework, or it may be cut in one of the applied panels. The valve consists of a framed and flush-paneled pallet of white pine, covered with soft felt and pallet-leather, hinged to a special frame or directly to the under side of the top-board, and so made as to open inwardly. The pallet is held against its seat by a couple of wire springs, while it is still more firmly bedded by the pressure of the wind in the receiver. The pallet is opened, when the receiver reaches its proper degree of expansion, by the pull of a cord which connects it with the middle-board below. The construction just described is shown in the Longitudinal Section, Fig. CCCLXX. A is the pallet, faced with felt and leather, and hinged at B. One of the pallet-springs is shown at C. The upper surface of the middle-board is indicated at D, to which the pull-down cord E is attached. This cord passes through a small hole in the pallet, where it is fixed at its proper length by the wedge F. G is the top-board or panel in which the valve-opening is cut. It is advisable to protect the pallet from dirt or anything likely to impair its proper action, and this is best done by fixing above it a frame over which thin flannel or some similar

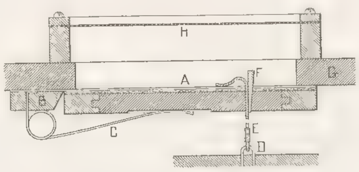


Fig. CCCLXX.

fabric is stretched, as indicated at H. This also silences the hissing noise of the escaping wind.

The remaining portions of the woodwork of the receiver are the floating-frame and the ribs, or those portions which, by means of leather strips and gussets, are joined to each other and to the trunk-band and top-board, completing the movable or expanding part of the appliance.

The floating-frame is made of the same length and breadth as the top-board. It is a simple frame of white pine of the form shown in Fig. V., Plate XII., consisting of side and end pieces, from ⅞ inch to 1½ inches thick according to the size of the receiver, and from ½ inch to 1 inch wider than the width of the ribs which are hinged to it. Small triangular pieces are securely glued and nailed in its internal corners as indicated. While these are convenient for the proper attachment of the gussets of the inverted ribs, they add strength to the floating-frame. In frames of large size additional strength and rigidity can be secured by inserting one or two narrow transverse bars.

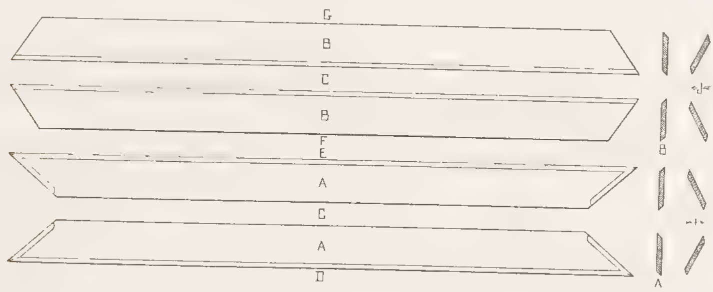


Fig. CCCLXXI.

The ribs of the receiver are pieces of clear, straight-grained white pine, from about ½ inch to ¾ inch in thickness, according to their length and the pressure they have to withstand. Their width varies, under usual conditions, from 4 inches to 6 inches, according to the "rise" decided on for the receiver. When the receiver is fully charged and the wind-supply stopped for the time, the ribs should stand at right angles to each other. Sixteen ribs are required in a receiver of the usual construction—four for each side and end. These are of two classes termed *direct ribs* and *inverted ribs*. In Fig. CCCLXXI. both classes are represented. At A are Face Views and Transverse Sections of direct or inward-folding ribs, and at B are similar representations of inverted or outward-folding ribs. At C are the edges that are hinged together, while the remaining edges are hinged, respectively, to the trunk-band at D, to the floating-frame at E and F, and to the top-board at G. All the parallel edges alluded to are splayed on one side and slightly rounded, as indicated in the several Sections, to facilitate their hinging and leathering. At I is shown the manner in which the direct ribs fold inward, and at J the manner in which the inverted ribs fold outward. The directions in which the ribs fold while the receiver is being exhausted are indicated by the small arrows. The

ends of the direct and inverted ribs are cut to different angles to allow of their opening and closing properly when connected by the leather gussets. At A in Diagram 1, Fig. CCCLXXII., are shown the proper angles and relative positions of the ends of the direct ribs, as they appear at the corners of the trunk-band, and when laid flat on the same. B is a Section of the upper edge of the trunk-band with the direct rib rising from it. At C in Diagram 2 are shown the proper angles and relative positions of the ends of the inverted ribs, as they appear at the corners of the floating-frame while laid flat thereon. D is a Section of the floating-frame with the inverted rib rising from it. The inner corner of the frame is here shown without the small angle-piece previously recommended. The ends of the inverted ribs may be left the full thickness of the wood; but those of the direct ribs should be chamfered on their outer edges as indicated at E. When all the sixteen ribs have been accurately dressed and shaped as directed, nothing remains to complete the receiver save the hinging and leathering of the same.

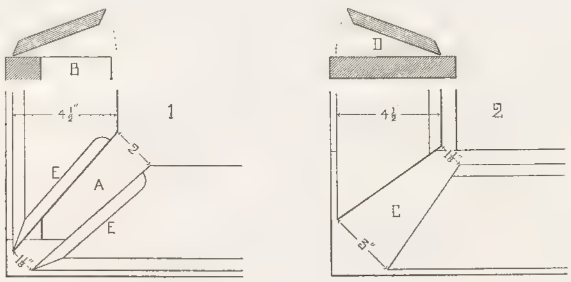


FIG. CCCLXXII.

Different organ builders follow methods of hinging and leathering slightly different in certain details, and in some cases employ different materials: but all reputable builders have one aim; namely, to make the receiver strong and durable, as air-tight as possible, flexible and strong in all its joints, and noiseless in its action. A perfect system of hinging and leathering, the use of the best materials, and thoroughly conscientious and skilled workmanship can alone secure these desirable results. The materials used in hinging and leathering the receiver are strained and specially-prepared white sheepskin, commonly known as bellows-leather, strong and thick chamois leather, and the strongest make of linen cloth. To these must be added large flat-headed copper tacks and the best quality of glue. The skins of bellows-leather should be carefully selected, of uniform thickness, and free from imperfections of any kind.* Chamois leather, which is tough and extremely pliable,

*This leather, required for joining the ribs together and to the trunk-band, floating-frame, and top-board, has to be evenly cut into strips of from 1½ inches to 2 inches in width, according to the thickness of the ribs or the width of their splayed edges. To accomplish this cutting in a satisfactory manner several methods may be adopted; but the following is both simple and expeditious: Prepare a perfectly straight rod of wood by dressing it square, so that each of its four sides is exactly the width required for the leather strips. This rod is to be used as the cutting straight-edge. The selected skin is spread out, with its undressed side downward, on a level but roughly-planed board, to which it will adhere sufficiently for all practical purposes. Now lay the square rod in position for the first or trimming cut, and draw a leather-cutter's knife,

has been used by some English organ builders for the strips by which the ribs are first bound to the trunk-band, floating-frame, and top-board; and as this fine leather has no hard dressed side and is extremely soft, it has some advantages to recommend it. The linen cloth, cut lengthwise in strips about 2 inches wide, is used for hinging the ribs, at intervals, together and to the other parts of the receiver. Such hinging should never be omitted; and thin leather, which has been recommended in certain quarters, should never be used for the purpose. In cheap work linen cloth has been frequently used instead of leather for the inside joinings of all the ribs; but this practice is to be strongly condemned. Labor and money may be saved, but the bellows are spoiled.

The first step in the hinging and leathering of the receiver is the joining together of the eight pairs of ribs along the edges indicated at C in Fig. CCCLXXI. Before any leather is applied, the ribs have to be hinged at places along their length, not exceeding a foot apart, by two pieces of the strong linen cloth before spoken of. These pieces have to be well glued and tacked to the ribs, so as to form crossed hinges, each piece being glued to the outside of one rib and the inside of the other, as indicated at A in Fig. CCCLXXIII., in which, for the sake of

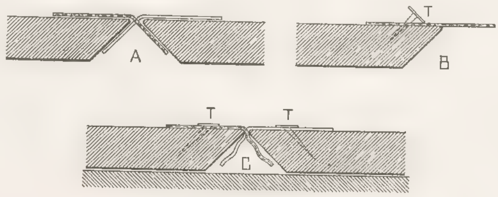


Fig. CCCLXXIII.

clearness, the cloth hinges are shown detached from the ribs to which they are to be glued, and the ribs are shown too far apart. The cloth hinges are cut a little less than the width of the leather strips which are to ultimately cover them, and are applied in the following manner: The ribs are placed in pairs and marked where the hinges are to be applied. Then the hinges are glued, placed in position, and securely tacked to the flat edge of each rib, as indicated at B. The copper tacks T are driven in obliquely and their heads hammered flat on the surface of the cloth, as indicated at C. When the hinges have been so far secured, the corresponding ribs are laid flat on a board, with their edges brought together and having the free portions of the hinges pressed down between them, as shown

sharpened at its point, along the adjusted side. Then, holding the rod firmly on the skin, turn it one-quarter round, leaving the first strip of leather exposed: cut this off; turn the rod again in the same manner and cut off the second strip. Continue this simple operation until the entire skin has been cut into strips. The strips must be cut the lengthwise of the skin and parallel to its true center line. When all are cut, they must be carefully examined, and all thin, weak, or otherwise imperfect strips or portions removed. Should there be any choice, the best strips should be reserved for the external leathering. The edges of all the strips must now be carefully skived on their undressed side, so as to be snug to the woodwork when glued. This is properly done with the skiving-knife while the leather is laid, dressed side downward, on a strip of plate-glass bedded in the face of a board. This careful method is frequently neglected in ordinary work.

at C. A pair of direct ribs so adjusted are shown at A in Fig. CCCLXXIV. Strips of leather prepared as before directed, skived on all their edges, are now saturated on their undressed side with boiling-hot glue, and immediately laid along the joint, over the linen hinges, and adjusted to the guide lines marked on the ribs. The strips must be well pressed and worked smooth with a slip of bone or ivory, fixed in a wooden handle, until the excess of glue has been removed and wiped away with a sponge dipped in hot water. The end strips must not be glued quite to the ends of the ribs, but only to about 1½ inches distance from them; and they must be cut so as to extend free about 1 inch beyond the ends of the ribs. These free ends will ultimately be glued to, and over, the edges of the gussets. The condition of the work at this stage is indicated at B in Fig. CCCLXXV. The first leathering, just described, on the direct ribs will appear

Fig. CCCLXXIV.

on the outside of the receiver when finished. The corresponding leathering on the inverted ribs will be on their inside faces, where no free ends will be required, the gussets being applied on the outside of the ribs. When the leather strips are dry, the ribs are folded together and held in that position by any convenient expedient. The free ends of the linen hinges are now well glued and laid on the splayed edges of the ribs, that previously laid on one rib being crossed over the folded leathering and laid on the other rib. The manner in which the hinges cross will be clearly understood on referring to Fig. CCCLXXIII. The hinges must be tacked to the splayed edges of the ribs in the manner above directed for their first attachment. When the hinging is finished, the splayed edges (still folded) are covered with strips of leather, glued, rubbed down, and sponged, in the same manner as were the first strips. In the case of the four pairs of direct ribs, this final leathering of their middle joints will be on the inside of the receiver, while the corresponding leathering of the middle joints of the four pairs of inverted ribs will be on the outside of the receiver. The end strips in this case must have short lengths left unglued and free to be subsequently glued over the edges of the gussets. If the linen hinging and double leathering have been carefully executed as above directed, the ribs will open and close easily and without any irregularity or undue friction. The crossed linen hinges effectually prevent the edges of the ribs rubbing against each other. Under no conditions of ordinary use can ribs so treated set up unpleasant noises in action.

Before proceeding to attach the several pairs of ribs, which have been hinged and leathered together, to the trunk-band, floating-frame, and top-board, it is necessary to join the four pairs of inverted ribs with their corner gussets. These gussets must be glued on while the ribs are closed and held in their proper relative position, because in this closed condition the ends of the inverted ribs are the maximum distance apart, and because the gussets can not be attached after the ribs are jointed and leathered to the floating-frame and top-board. The reverse is the case with the direct ribs, which must be gusseted after they are hinged and leathered to the trunk-band and floating-frame, and while they are opened to the extreme angle to which they will be required to move, because at this angle their ends are the maximum working distance apart. The four pairs of inverted ribs are prepared for gusseting by being folded and laid flat, in their exact relative positions, on the surface of the floating-frame, and fixed together adjoining their ends by four temporary strips of wood nailed or screwed to the ribs. So secured, the ribs can be lifted from the floating frame and turned over in the process of gluing on the gussets.

The exact shape and size of the gussets are now taken from the folded ribs by means of a paper pattern; and the four gussets are cut from specially strong, sound, and pliable sheepskin, and their edges well skived. The form of the gussets is shown at A in Fig. CCCLXXV., while at B a gusset is shown glued to

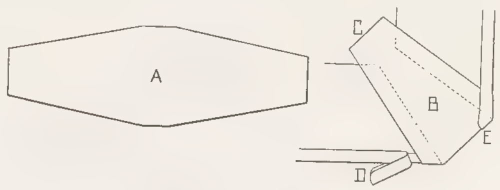


FIG. CCCLXXV.

the two ends of two pairs of inverted ribs. In gluing the gussets on, the ends of the outside leather strips, left unglued as previously directed, must be turned back in the manner indicated at D. When the gusset is properly glued, and all its edges in contact with the ribs are rubbed down tight, and cleaned off with a sponge and hot water, the free ends of the strips are well glued and rubbed down over the gusset at the corners of the ribs, as indicated at E. The free ends of the gusset at C are for attachment to the floating-frame and top-board.

There are different methods of executing the hinging and leathering of the outer edges of the ribs to the trunk-band, floating-frame, and top-board; but all of these, so far as our observation extends, with the exception of one method of unquestionable merit, appear to be compromises, involving expedients for the saving of time and money—unwise expedients in the construction of so important a fabric as the lungs of the Organ. A bellows can be made to look well, and to pass through a close examination by those who are not acquainted with the proper method and the niceties of its construction; and even a bad bellows may last for

some months without showing any obvious signs of weakness, but in the order of things its useful life is a short one. To hinge and leather the ribs to the trunk-band, floating-frame, and top-board, in the most workmanlike and durable manner, the following directions must be observed. A sufficient number of strips of strained sheepskin must be cut and skived, as already directed for the middle joining of the ribs, to double-joint the sixteen outer edges of the ribs of the receiver; and numerous pieces of the strong linen cloth, 3 or 4 inches by 2½ inches, must be cut, to serve as hinges for the joints which remain to be made. These hinges do not cross in the manner previously described, and, accordingly, are made longer, and placed somewhat closer together. Both the leather strips and the cloth hinges must be tightly folded lengthwise, so as to produce a well-marked crease along their centers. One half of the leather strips must be folded with their dressed sides together, and the other half with their rough sides together. Before proceeding with the gluing operations, lines should be marked on the trunk-band, floating-frame, and top-board, indicating the exact positions of the edges of the ribs resting against them. The lines on the top of the trunk-band and on the under side of the floating-frame should be marked about ¼ inch from their outer edges, for the adjustment of the direct ribs, while the lines on the upper side of the floating-frame and the under side of the top-board should be about 4¾ inches from their outer edges, supposing the inverted ribs to be 4½ inches in width. The first step in the gluing-on process is to glue one half of each folded cloth hinge, and lay it in proper position along the lines just mentioned, leaving the other halves free to be subsequently glued to the ribs. The hinges are to be further secured by copper tacks. In Plate XIII. are given a series of Transverse Sections showing the different stages of the hinging and leathering. At A is the upper edge of the trunk-band; at B the floating-frame; and at C the top-board. In all the Sections the cloth hinges are indicated by thick black lines, and the leather strips by double thin lines. In Series 1 is represented the first step in the process under consideration. At D and D^1 are shown the folded cloth hinges in proper positions for the direct ribs; and at E and E^1 the hinges in proper position for the inverted ribs. The second step in the process is to glue the strips of leather, which have been folded with their dressed sides together, to the trunk-band, floating-frame, and top-board, along the lines marked on them, and over the portions of the hinges already fixed. The rough sides of the strips must in all cases be toward the hinges. Before gluing the strips, the half of their dressed sides which will ultimately be glued to the ribs must be well scratched. This second step in the process is represented in Series 2. At F and F^1 are shown the cloth hinges and the folded leather strips for the direct ribs; and at G and G^1 the same for the inverted ribs.

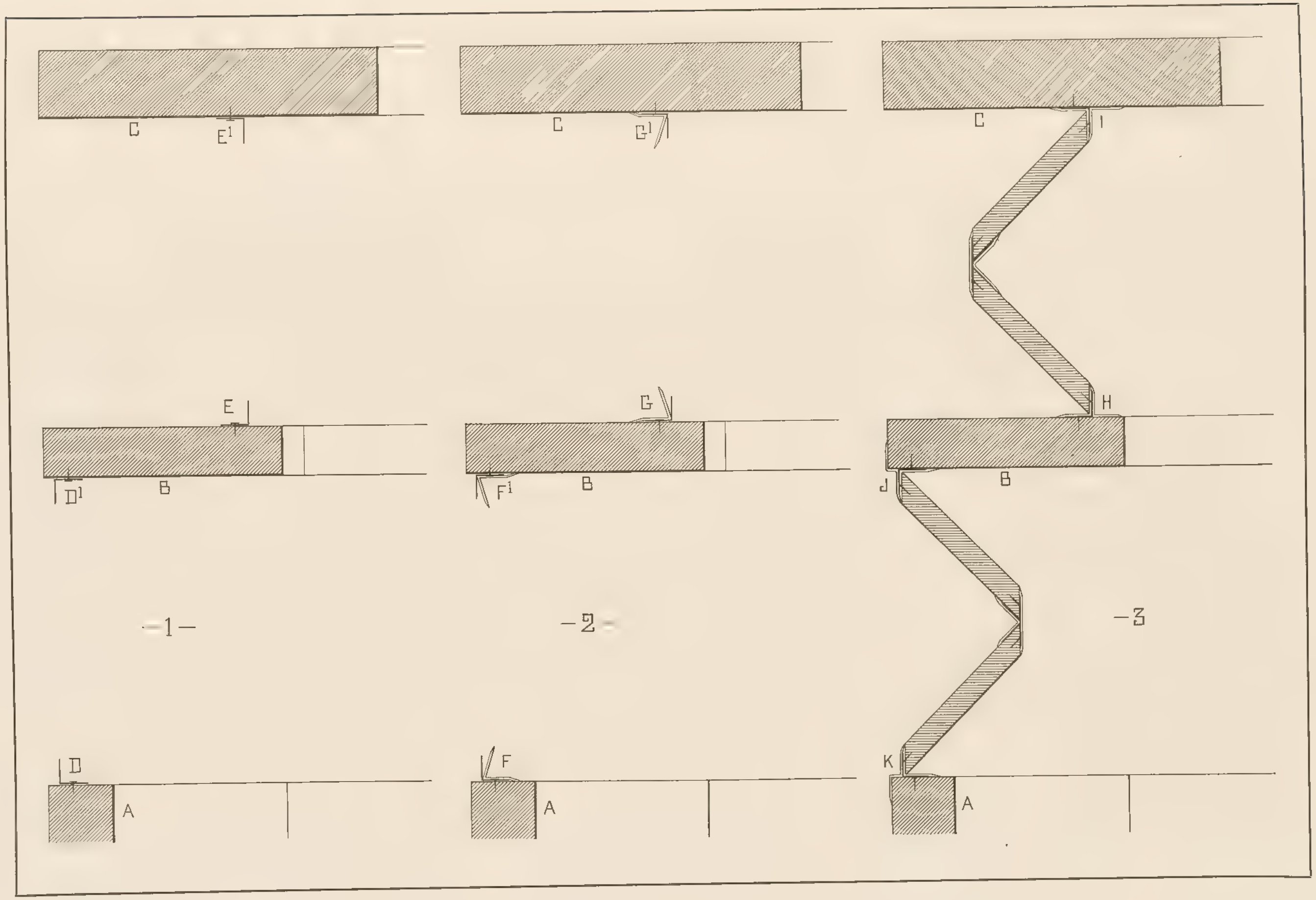
At this stage the trunk-band, floating-frame, and top-board, are ready for the ribs, which are attached in the following manner: The inverted ribs, which have already been joined together and gusseted, are laid upon the upper surface of the floating-frame, with their lower splayed edges adjusted to the creases of the leather strips and hinges at G. These leather strips and the splayed edges of the lower ribs are now coated with boiling-hot glue, and a perfect contact made by

the leather being firmly rubbed close with the bone tool, and warmed by the application of a hot sponge as required. The linen hinges are then securely glued to the leather on the edges of the ribs, and subsequently firmly attached by copper tacks driven through them and the leather into the wood. When the glue is dry, the other strips of leather, which have been folded with their rough sides together, are cut to the required lengths and skived at their ends : but before they are glued on, the lower free ends of the gussets (shown at C in Fig. CCCLXXV.) are glued down securely to the inner corners of the floating-frame, and further secured by over-lays if considered advisable. The strips of leather are now saturated with very hot glue, and laid over the linen hinges and the leather along the edges of the ribs, and down on the adjoining portion of the floating-frame, being well rubbed to all the surfaces and into, and over, all angles, hot sponged, and carefully cleaned off. The attachment as described is indicated at H in Series 3, where the disposition of the two leather strips and the linen hinge is indicated as clearly as practicable. When this first attachment is perfectly dry, the floating-frame and the ribs are turned over and laid in correct position on the under surface of the top-board, the ribs falling into the creases of the leather strips and linen hinges previously attached to it at G^1. The remaining free ends of the gussets are first glued down to the top-board, and then the leather strips and linen hinges are securely glued and tacked to the edges of the ribs, as in the attachment of the other ribs to the floating-frame. When the ribs can be safely moved, the floating-frame is raised and propped up sufficiently to allow the second leather strips to be conveniently and properly glued on. This finished attachment is indicated at I.

While the upper portion of the receiver just completed remains in its inverted position, the direct ribs are laid on the surface of the floating-frame, in their correct relative positions, and with their lower edges adjusted to the creases of the leather strips and cloth hinges indicated at F^1. These strips and hinges are now securely glued and tacked to the splayed edges of the ribs, as in the case of the inverted ribs; and, subsequently, the outside finish-strips are applied over all, carefully worked into, and over, all angles, rubbed down, and sponged clean. This third attachment is indicated in its complete state at J. When all is dry, the entire portion, leathered as above described, is turned and laid in correct position on the top of the trunk-band, the edges of the lower direct ribs fitting exactly into the creases of the leather strips and hinges indicated at F. This attachment is executed in precisely the same manner as the preceding, and is indicated in its finished state at K. Nothing now remains to complete the leathering of the receiver but the attachment of the four gussets to the direct ribs.

The floating-frame, carrying the inverted ribs and top-board, is now raised until the direct ribs are opened equally around the receiver to the fullest extent they are ever likely to be opened in the actual operation of the bellows, or, say, to about the angle of 50°. Then, by means of several props of wood, placed in the inside of the receiver, between the middle-board and floating-frame, the direct ribs are temporarily held in this open position. The ends of the direct ribs are now the maximum distance apart at their inner angles, and are, accordingly, in the

PLATE XIII



proper position to receive their gussets, as indicated in the Corner View 1 in Fig. CCCLXXVI. The exact form and dimensions of the gussets are taken by a paper pattern, from which the leather is cut. The gussets, after having all their edges carefully skived, are securely glued to the splayed ends of the ribs, overlapping the ends of the leather strips already attached to the outer edges of the ribs, the trunk-band, and floating-frame. The ends of the outside middle strips, left unglued as previously directed, shown at A, are now glued carefully on, and over, the corners of the gussets, as indicated in the Corner View 2. The gusseting is completed by the addition of corner shields, cut from very soft leather of medium thickness, in the form shown at B. These shields are well skived so as to give them thin and very pliable edges; and after being damped with hot water, and coated on their undressed sides with thin glue, they are laid over the outer ends of the gussets and the corners of the trunk-band and floating-frame, in the positions

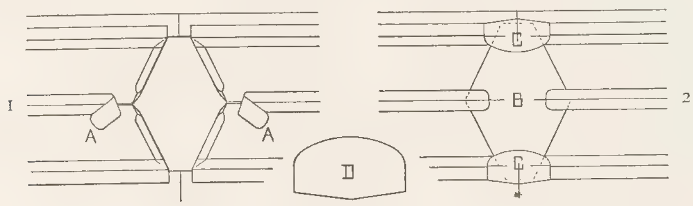


Fig. CCCLXXVI.

indicated at C, and well worked, by means of the bone tool and hot sponge, into every crease and depression of the leathering previously executed, and until they adhere perfectly to the surface of the gussets. In calculating the width of the gussets, allowance must be made so that they will be quite slack at D when finished and before the props are removed.

All the woodwork of the receiver should be thoroughly protected against the action of damp and drought. For this desirable end we advise the uncovered surfaces in the interior, except where the leather valves rest, to be painted with two good coats of best white lead and linseed oil, or, if preferred, with a coat of size and two coats of hard-drying oil varnish. The exterior of the receiver, when constructed of the best white pine, should have all its unleathered surfaces sized and covered with two coats of the best spar or floor varnish. Paint is often applied to hide inferior wood and indifferent workmanship. Shellac varnish is frequently applied to good woodwork, but, while it looks well, it is not sufficient protection in a changeable climate. We may add here that the above directions and remarks apply to all portions of the bellows-work—receivers, reservoirs, feeders, wind-trunks, etc.

It is essential that while in action the receiver or reservoir should rise and fall with all its ribs exactly equal and with its floating-frame and top-board parallel to the middle-board, which remains horizontal and stationary. This parallel motion is secured by simple appliances commonly called regulators, and incorrectly termed

"counterbalances" by some writers on the Organ. By means of these appliances the floating-frame is at all times supported exactly midway between, and truly parallel to, the upper edge of the trunk-band and the under side of the top-board, securing at every stage of inflation a precisely similar extent of angular motion in both the direct and inverted ribs. Different forms of regulators have been invented, but as they are all constructed on the same principle, or for the same purpose, it is only necessary for us to describe and illustrate the form which is the simplest and most compact, and perfectly efficient in its action. This form, which may be designated the Z-regulator, is shown in Fig. CCCLXXVII. A is the trunk-band, B the floating-frame, and C the top-board, between which are the direct and inverted ribs. The regulator D is formed of three pieces of soft steel, $\frac{3}{16}$ inch thick and about $1\frac{1}{4}$ inches broad, the middle piece being somewhat less than twice the length of each end piece. The pieces are drilled and connected by means of two pivots $\frac{1}{4}$ inch in diameter, riveted in such a way as to allow them to move easily, having a thin brass washer between them. The middle piece is pivoted to the edge of the floating-frame by means of a strong screw passing through its center and the two necessary brass washers. The end pieces are pivoted in like manner to the trunk-band and the top-board. Thick washers of hard leather must be placed between the end pieces and the woodwork so as to prevent any twisting or bending of the regulator. For large and heavy receivers, it is desirable to construct the regulator with three plates, having projecting pivots on which the middle and end pieces will work noiselessly. These plates should be 4 inches long and $1\frac{1}{4}$ inches wide, drilled and countersunk for four screws each, so that they can be firmly fixed to the trunk-band, floating-frame and top-board.* The number of regulators required will vary with the size of the receiver or reservoir; but except on those of square form and very small dimensions no fewer than four should be applied. On a receiver of oblong shape and ordinary dimensions two regulators should be fixed on each of the longer sides, a short distance from the corners, so as to secure a well-balanced bearing and a true parallel motion. The pair of regulators on each side should fold in opposite directions to counteract

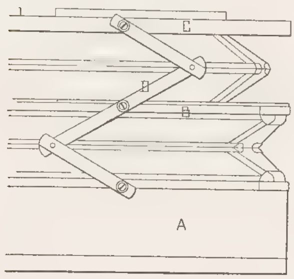


FIG. CCCLXXVII.

*A regulator has been frequently used by German organ builders, which is a combination of two regulators of the form shown in Fig. CCCLXXVII., consisting, accordingly, of six pieces pivoted together. When only one regulator is applied to each end of a small receiver, this double form may have some slight advantage over the single form. An illustration of the double form is given in Fig. 9, Plate XXV. of "Die Theorie und Praxis des Orgelbaues." Another regulator constructed with a long middle bar and two short arms has been used by some builders. A somewhat exaggerated treatment of this form is shown in Fig. 199, Plate XVI., of Robertson's "Practical Treatise on Organ-Building." Two very objectionable forms of regulators are illustrated in Figs. 6 and 7, Plate XXVI., of "Die Theorie und Praxis des Orgelbaues." In both forms the regulators extend above the top-board of the receiver when it is closed. Still more objectionable forms are those which simply keep the top-board parallel to the stationary part of the receiver, without engaging the floating-frame.

any possible strain. To secure a noiseless action, all the joints of the regulators should be lubricated with a paste of pure tallow and black-lead.

Pressure has to be applied to the top-board to impart the required degree of compression to the air within the receiver. Until recent years this has been done by placing weights, preferably in the form of plates or bars of cast-iron, on the upper surface of the top-board; now a series of V-shaped or spiral springs are sometimes substituted for the weights. When V-shaped springs are used they are placed so as to bear directly downward on the surface of the top-board; and when spiral springs are used they are placed alongside the receiver, and fixed so as to pull the top-board downward with a properly-adjusted force. All these methods are attended with disadvantages. In the case of weights laid directly on the top-board, there is always a considerable inertia to be overcome at every movement after rest. This has a decided tendency to make the organ-wind unsteady and of varying pressure. To remove this defect it has been suggested to interpose springs between the weights and the top-board.* In the case of springs alone, it is quite obvious that the proper pressure of the organ-wind can only obtain when the springs are at one definite point in their action; and that, unless the receiver can be kept at the exact degree of inflation necessary to bring the springs to that definite point in their action, the pressure of the organ-wind will continually vary.

We must not pass from the consideration of the receiver without adding a few words regarding the adoption of the two forms of ribs—the direct or inward-folding, and the inverted or outward-folding. That a certain advantage has been found to attend the adoption of the different forms seems to be very generally conceded; but we are of opinion that more has been claimed than can be reasonably admitted. The combined action of the direct and inverted ribs must, of course, have some effect on the volume of compressed air within the receiver; but, when the wind-supply is thoroughly efficient and continuous, and the receiver is kept charged to nearly its full capacity, we venture to assert that the influence of the ribs is much less than is generally believed. There has been a diversity of opinion respecting the action of the ribs; and, so far as our knowledge extends, the true explanation has alone been given by Mr. F. E. Robertson, in his valuable "Practical Treatise on Organ-Building." For this author's learned dissertation on the subject we must refer the reader to the pages of the above-named work (pp. 161–164) and the illustration accompanying the same (Fig. 128, Plate XII.).†

* On this subject Mr. F. E. Robertson remarks: "It would be an improvement if, instead of putting the weights directly on the top-board of the bellows, springs were interposed, because the action of the weights is not instantaneous, whereas that of a spring is. Suppose a reservoir which, with 12-inch fall, can supply the full organ for 10 seconds. A full chord struck will require the top-board to descend at the rate of 1·2 ft. per second; but it requires $\frac{1}{25}$th of a second before it can fall that distance, during which time the efflux of the air is supplied by its own elasticity, and not by the weights—i. e., the pressure falls. With springs, however, the weight will follow up every movement of the top-board instantaneously and keep the pressure uniform." "A Practical Treatise on Organ-Building," p. 174. To us some statements made in the above quotation seem somewhat obscure.

† The true reason for the adoption of both direct and inverted ribs in the construction of the receiver does not seem to have been generally understood; and in all probability the passages on the subject in Dr. Hopkins' work,—"The Organ,"—which for nearly half a century was the recognized text-book on the art of organ-building in the English language, have done much to create an erroneous idea. We are told in this

The term Reservoir, as already mentioned, is correctly applied to an auxiliary chamber, identical in general form and construction with the bellows-receiver, which is placed in any desirable locality in the Organ, and which is charged with wind from the receiver. While there may be only one general receiver, there may be several reservoirs distributed throughout a large Organ, each of which may be weighted to yield a wind of different pressure. The several parts of the reservoir bear the same names as the corresponding parts of the receiver, with the exception of the stationary board which carries the expanding portion. This is correctly called the bottom-board, because, with the exception of the wind-trunks which supply and exhaust the reservoir, there is nothing attached which belongs to it. A properly-constructed reservoir has direct and inverted ribs, floating-frame, top-board, and regulators, formed and put together in the manner already directed for the construction of the receiver. The reservoir may have a trunk-band attached to its bottom-board, if height will permit, and if it will be convenient for the wind-trunks to and from it.* The reservoir must be fitted with regulators and weights or springs in the manner directed for the receiver. When fitted with an automatic

work that in making the inverted ribs fold *outward*, while the direct ribs are made to fold *inward*, the former give just so much more space for the inclosed air as the latter give less ; and, accordingly, that the disadvantageous influence of the one set of ribs is counterbalanced by the advantageous influence of the other set. And, further, we are told that the action of the inward-folding ribs of the old diagonal bellows, by pressing wedge-fashion into the confined air had the result of imparting greater pressure to it. Neither of these explanations is, however, correct. The true state of affairs is that the horizontal pressure of the inclosed air against the ribs tends to force the direct ribs outward and wider apart, thereby assisting to sustain, by a species of "toggle-joint" action (to use Mr. Robertson's term), the top-board of the receiver; while, at the same time, the horizontal pressure acting on the inverted ribs tends to force them outward and closer together, thereby giving less mechanical support to the top-board and its load. As these forces, or their contrary effects, counterbalance each other, the pressure of the air within the receiver remains, for all practical purposes, uniform at all stages of the receiver's motion. These particulars respecting the action of the compressed air on the ribs of the receiver clearly show that the explanations given by Dr. Hopkins, and very widely accepted, relating to the wedge-like action of the inward-folding ribs of the old diagonal bellows, and the equalizing of the air-space, by the reversed ribs, within the receiver, are neither logical nor correct.

It is true that the action of the direct ribs, which were the only kind used in the diagonal bellows, was found to create irregularity in the pressure of the organ-wind ; but this was due to the fact, among others equally potent, that in the process of delivering its compressed air the diagonal bellows entirely emptied itself, and the inclosed air was all the while exerting a varying force on the inner surfaces of the ribs. Various mechanical expedients were devised to counteract this varying force, but it is unnecessary to describe them here.

* In certain important French Organs, notably in the Grand Organs in the Churches of Saint-Sulpice and Saint-Eustache, at Paris, are introduced large receivers and reservoirs of the same size and construction, the expanding portions of which have double tiers of direct and inverted ribs, supported between their trunk-bands (or their equivalents) and top-boards by three floating-frames. In the Organ in the Church of Saint-Sulpice, built by Cavaillé-Coll, the double-tiered reservoirs have an unusually complete system of regulators. Each receiver has four zig-zag regulators (or double Z-regulators), for the purpose of keeping the three floating-frames at equal distances from each other and from the trunk-band and top-board. Two large and strong regulators, attached to the trunk-band and top-board only, constitute a parallel action, which retains the top-board in a perfectly horizontal position at all times, and, accordingly, prevents any cross-strain falling on the numerous ribs. In the same Organ there are small reservoirs constructed with only one set of direct ribs. These are placed directly under the wind-chests, and are connected therewith with accordion wind-trunks. The adoption of reservoirs of this simple form goes to prove that, given a regular and constant supply of wind from the bellows, there is no absolute necessity for inverted ribs. In the Organ in the Church of Saint-Eustache all the reservoirs belonging to the different divisions are constructed with double tiers of direct and inverted ribs. We are not aware of receivers or reservoirs having double tiers of ribs, as above mentioned, ever having been used by English or American organ builders: with a proper feeder arrangement or adequate blowing apparatus they are certainly unnecessary. As we have said before, it is not the capacity of the receiver or reservoir that controls the wind-supply, that begins and ends with the efficiency of the feeders or blowing-appliances.

supply-valve, a waste-valve may not be necessary, but we recommend the insertion of a small one, placed on the inner surface of the bottom-board, and opened by a cord attached to the top-board.

There are several forms of automatic supply-valves applied to the reservoir, but it is only necessary to describe and illustrate one very satisfactory form here. This valve is properly used in the band-receiver in which sufficient depth obtains for its efficient action. In Fig. CCCLXXVIII. is given a Section through the central portion of a reservoir, showing the supply-valve partly in section and partly in side view. The valve A, framed and flush-paneled as indicated, is hung on center pivots in the accurately-fitted frame B. Its best form is square, and it must be of ample size to admit all the wind that can possibly be required. Although this valve may open from an ordinary wind-trunk, it is specially suited for an accordion trunk, as indicated at H. Two of its edges, parallel to its pivots, are sloped and covered with felt and soft leather. These bed truly against corresponding slopes in the frame B. The two other edges are dressed square so as to fit closely, without undue friction, against the corresponding edges of the frame to which the valve is accurately pivoted in its center. The square edges of the frame should be covered with thin, strained bellows-leather. This covering provides the friction required to hold the valve in any position it may be placed by the movement of the top-board. To the upper surface of the valve is attached the lever-arm C, carrying the small hardwood wheel D, which runs against the inclined block E, fixed to the top-board F. The arm C is linked to the top-board by the adjustable cord G in the manner clearly shown. The action of the appliance is very simple and efficient. So soon as wind is drawn from the reservoir, the top-board falls until the block E comes in contact with the wheel D, when it depresses the arm C, and opens the valve A. When the supply through the valve exceeds the demand for wind, the top-board rises without moving the arm until the slack of the cord G is gathered up, when the arm is raised and the valve is closed, as shown. The advantage of this arrangement is obvious: by connecting the arm with the top-board by a cord which communicates motion only at intervals, any sudden motions of the top-board, caused by *staccato* playing or the reiterated sounding of heavy chords, are not communicated to the supply-valve, and, accordingly, an extreme disturbance of the organ-wind is prevented. The positions of the several parts of the appliance when the reservoir is empty are indicated by the dotted lines.* This form of automatic supply-valve, being balanced so far as the action

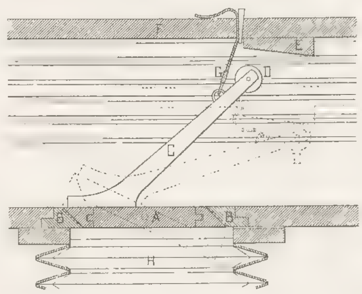


Fig. CCCLXXVIII.

* The generality of organ builders are content to use a much simpler and less satisfactory supply-valve than the one just described. In its usual form it consists of a large pallet, hinged to the under side of the

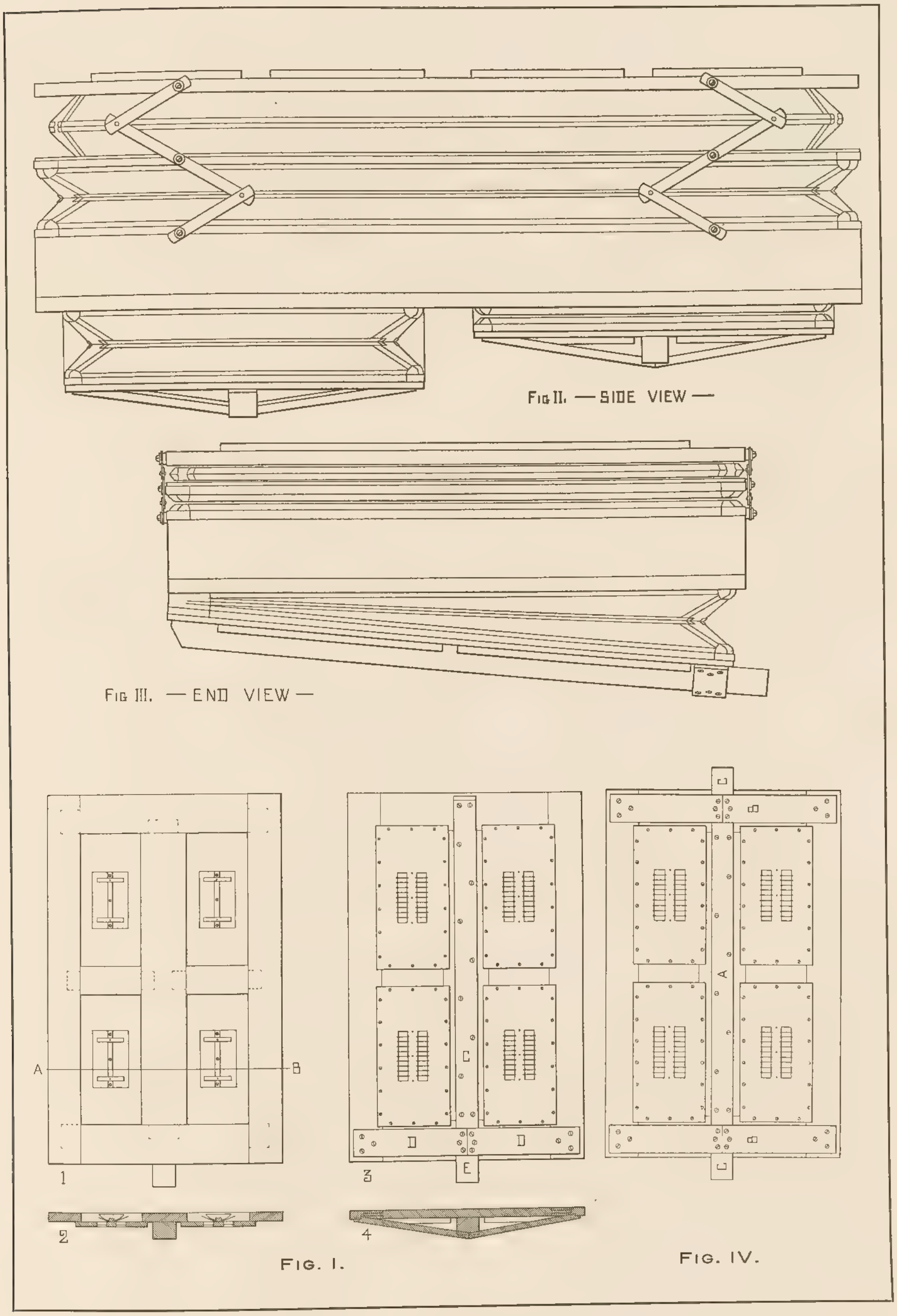
of the compressed air on both its sides is concerned, is admirably suited for reservoirs of low pressure which are fed from those of higher pressure. Of course, it is impossible to fill a high-pressure reservoir from a low-pressure one by means of any automatic appliance. It is by a skilful arrangement of several reservoirs that different pressures of wind in a large Organ are readily obtained. The reservoirs of very heavy pressures, for the service of the TUBAS and other powerful stops, are fed directly from special bellows or blowing-engines, and are not connected with any other reservoirs in the way above described.

There are different forms of the compound bellows from which two pressures of wind are supplied without the intervention of a reservoir. One of the simplest of these is the invention of Mr. Philipp Wirsching, of Salem, Ohio. In this compound bellows the wind from the feeders passes into a horizontal chamber and thence directly into a receiver placed over one half of its surface. The chamber and receiver just alluded to contain the wind of high pressure. Over the other half of the chamber is placed another receiver, fed through a simple automatic valve from the high-pressure chamber. This receiver furnishes the low-pressure organ-wind. A bellows of this construction is very serviceable in an Organ of small size, in which two pressures of wind are required, either for the pedal and manual departments or for the mechanism and the pipe-work.

We have now to describe the parts of the compound bellows by which the air is collected and forced into the receiver; these parts are properly designated the Feeders. There are several forms of feeders introduced in modern Organs, the more important and generally-used of which are the hinged or cuneiform feeder, the parallel or whole-drop feeder, and the vertical double-action feeder. There is another form of double-action feeder designated the cuckoo feeder, which has been frequently introduced in small Chamber Organs, but this may be classed among the curiosities of organ-building.* The hinged and whole-drop feeders are usually single-action, and may be operated either by hand or some simple form of motor; but the vertical double-action feeders are invariably operated by a motor, preferably a water engine. The feeder originally introduced in the compound or horizontal bellows, and the one that still continues in general use in Organs of moderate size, blown by hand or some simple motor, is the hinged or cuneiform. In a properly-constructed compound bellows one hinged feeder should never be intro-

bottom-board, and held against its seat by a spring. It is placed within the trunk through which the organ-wind is conveyed from the bellows or from another reservoir. Fixed to the inside of the top-board is a pendant rod of wood, of a length sufficient to press down and open the pallet when the reservoir is partly collapsed. This essentially imperfect valve is the only one mentioned and illustrated in Robertson's "Practical Treatise on Organ-Building" (Paragraph 304. Fig. 198, Plate XVII.). Cavaillé-Coll has used a somewhat improved form of this primitive valve, between two reservoirs, in the Organ in the Church of Saint-Vincent-de-Paul, Paris, placing the pallets inside the top-board of the lower reservoir, and providing the opening-rod sufficiently long to pass from the top-board of the upper reservoir down through the connecting accordion wind-trunk to the pallets. As the valve is attached to the movable top-board of the lower reservoir, and the rod to the top-board of the upper one, the action of the appliance is compound. Illustrations of this valve are given in the Section of the Organ on Plate LV. of "Die Theorie und Praxis des Orgelbaues," and in the Diagram of superposed reservoirs given on page 29 of "Die Orgel und ihr Bau" (Leipzig, 1887).

* There are short descriptions of the cuckoo feeder and its variant, the rocking double feeder, given by Hopkins in "The Organ." Second Edition, page 21.



duced. For hand-blowing by means of the ordinary rocking handle, two such feeders are necessary; and when a crank action is adopted, worked by hand or an electro-motor, three feeders should always be adopted, securing an absolutely continuous supply of wind. The feeders form the lower part of the compound bellows, being attached to the under side of the middle-board, which forms the bottom of the receiver, as already described.* They should in all cases be made as large as possible, and have as deep a fall as space and the mode of actuating them will permit. When actuated by the ordinary hand-rocking lever, the two feeders may with advantage be made of different widths, the larger one being linked to the end of the lever farthest from the hand, so that it may be drawn up by the downward stroke of the blower, and by its greater weight slightly assist his weaker upward stroke: but when the feeders are actuated by a crank-shaft, either turned by hand or a motor, they must be of equal size. When a crank-shaft is used, three feeders should always be introduced, as already mentioned.

The woodwork of the hinged feeder comprises a framed and paneled bottom-board fitted with strengthening-bar and lug-piece, two narrow hinge-strips, and six ribs. A mortised and tenoned frame has to be added to these when the feeder is finished independently of the receiver. The bottom-board has to withstand a considerable strain, and should be strongly constructed. It may be formed of a mortised and tenoned frame, from 1½ inches to 2½ inches thick, according to the length and width of the feeder, filled in with flush panels, or having applied panels screwed on in the fashion already directed for the middle-board of the bellows. A solid bottom-board should be adopted only when the feeder is hinged and leathered to a frame, so as to be easily detached from the middle-board. The valve-openings or "suckers" are cut through the panels, and have leather valves applied to them on their inner surfaces in the manner shown in Fig. II., Plate XII. Suckers in the form of single circular holes covered with small leather valves, distributed at equal distances over the bottom-board, are frequently used. Care must be taken to have suckers of sufficient size or number to prevent any gasping or sluggishness in the action of the feeder. In Fig. I., Plate XIV., are given diagrams of the bottom-board of a hinged feeder. Diagram 1 shows the upper or inside of the board, with its strong framework, applied panels, and its series of valves. Below this, in Diagram 2, is a section cut on the line A—B, showing the applied panels and the central strengthening-bar. Diagram 3 shows the under or exposed side of the bottom-board in its complete state. The applied panels are pierced with eight suckers of the best form, corresponding to the valves indicated in Diagrams 1 and 2. Along its center is securely fixed the strengthening-bar C, prolonged at the free end of the board to form the lug E, to which the blowing mechanism is ultimately attached. The two pieces of wood D are let into the bar C, notched into the side pieces of the framework, and securely screwed thereto as indicated. These pieces form a truss which imparts the neces-

* The feeders are either hinged and leathered directly to the surface of the middle-board, or to independent frames which are subsequently screwed to the framing of the middle-board. While the former method is that most frequently followed, the latter is to be strongly recommended, as it gives increased rigidity to the entire bellows, and allows the feeders to be readily removed for repairs, etc.

sary rigidity to the entire board. The manner in which the truss is fitted is shown in Diagram 4. When the feeder is very large, a second truss may, with advantage, be formed in the middle of the board, between the panels.

The remaining more important portions of the woodwork of the feeder are the ribs. These are direct and of two forms: those for the sides being long and tapered, as shown at A in Fig. CCCLXXIX., and those for the end of the feeder

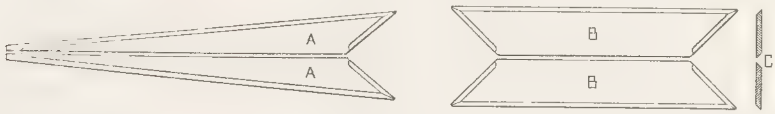


Fig. CCCLXXIX.

being quadrangular, of the form shown at B. Four of the former and two of the latter are required for each feeder: all are splayed along their outer edges, as indicated at A and B, on the inner side of their meeting edges at C in the Section. The ribs should be made of straight-grained white pine, about ⅝ inch thick for feeders of ordinary size and wind of moderate pressure. The width of the ribs will be dictated by the dimensions of the feeder and the drop decided on. At the full drop, the angle formed by the ribs should be about 45°. The tapered ribs at their widest part are not quite so wide as the front parallel ribs. The respective widths are shown in Fig. CCCLXXIX., and the manner in which the respective widths and forms of the ribs are determined is shown in Fig. CCCLXXX. The outer line represents the bottom-board; A and B are the ribs laid in correct position upon it. The lines C and D are drawn at a distance from the corners equal to the width decided on for the end ribs A; and the lines C determine the form and dimensions of the side ribs B. The correct angular spaces between the ribs for the gussets have to be allowed, as in the case of the direct ribs of the receiver. The ends of the side ribs are cut off at E to allow of the proper hinging and leathering of the feeder. The woodwork is completed by the addition of two hinge-strips, which are glued and screwed to the middle-board and bottom-board, as indicated at A in the Transverse Sections given in Fig. CCCLXXXI. These strips extend the entire width of the feeder, and have their inner corners cut away so as not to bind the leather at the ends of the ribs. The form and position of these strips are indicated at F in Fig. CCCLXXX.

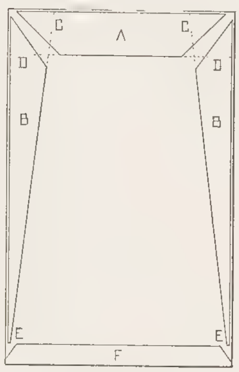


Fig. CCCLXXX.

The process of hinging and leathering the ribs is in all essentials similar to that already described in connection with the direct ribs of the receiver. It must

be borne in mind that a feeder is subjected to much more wear and tear than a receiver, and that, accordingly, it must be made stronger in all its working parts. Stout linen cloth must be liberally used for the hinges of the ribs; and the leather used must be of the finest and strongest quality. Specially thick and pliable pieces must be selected for the gussets, and in the case of feeders delivering wind of high pressures, double gussets should be applied. There are different methods of forming the portion of the main hinge which has to withstand the strain of the feeder in action: of these two only need be described here. The older method, which we find illustrated in Dom Bedos' great treatise, and which has been recommended in all the important treatises subsequently published, is by no means generally adopted by organ builders to-day. This time-honored method, however, still remains the most reliable, and we join the other advocates in recommending it.

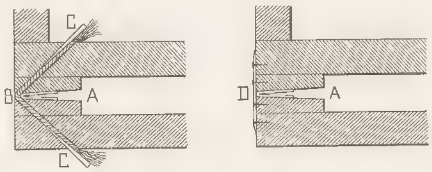


Fig. CCCLXXXI.

This hinge is formed by boring a series of holes in an oblique direction through the hinge-strips and the middle- and bottom-boards, through which is drawn very thick catgut, or several pieces of whip-cord twisted together, as indicated at B in Fig. CCCLXXXI. These cords are pulled tight, well glued, and wedged at C: and after the projecting pieces of the wedges are cut away, their ends are untwisted and frayed, spread out, and glued down to the surface of the boards, and finally protected by pieces of leather.* Before the cords are inserted the inner fold of thick leather must be glued between the hinge-strips, as indicated in the Sections. Before any external leathering is applied to the hinge, a strip of linen cloth should be glued and tacked along the joint at B. The other method of hinging the feeder commonly adopted at the present time for ordinary bellows, consists (after the insertion of the folded strip of leather between the hinge-strips) of the application of a strip of linen girth-webbing or very thick canvas along the joint, as indicated at D. This must be well glued and secured with large tinned copper tacks to the hinge-strips and boards, forming a continuous hinge along the end of the feeder. When all the leathering of the ribs has been executed in the manner described for the leathering of the direct ribs of the receiver, the feeder is completed by gluing a broad band of thick bellows-leather along the hinge and around the corners until its ends extend a few inches over the small ends of the side ribs, to which they are carefully glued, making everything perfectly air-tight.

* The number of cords required varies with the width of the feeder and the work it has to do. In the diagonal bellows illustrated by Dom Bedos in "L'Art du Facteur d'Orgues," and copied thence by Töpfer in "Die Theorie und Praxis des Orgelbaues," fourteen cords are used, arranged in two end groups of five and a central group of four. In old work, sinews of the horse were often used.

In Figs. II. and III., in Plate XIV., are given Side and End Views of a horizontal or compound bellows in its complete form, showing the feeders and the receiver in their relative positions. In the Side View, Fig. II., the receiver is shown fully inflated, while in the End View, Fig. III., it is shown collapsed. No style of blowing action is shown.

In all cases where the bellows is conveniently located outside the Organ, and a water-motor is used for blowing, whole-drop feeders should be adopted in preference to hinged or cuneiform ones. Whole-drop feeders have practically twice the cubical contents of hinged feeders of equal superficial measurement and drop, and, accordingly, deliver about twice the volume of air at each upward stroke. The comparatively slow movement necessary for the whole-drop feeders is a matter of considerable importance, first, as it tends to perfect steadiness of the wind-supply, and secondly, as it favors the best form of power blowing; namely, by water-motors. The whole-drop feeders properly occupy the same positions under the middle-board of the receiver as the hinged feeders do. While it is desirable to have the whole-drop feeders as nearly square as possible, their forms will, of course, be dictated by the form of the middle-board of the receiver.

The whole-drop feeder presents no specially new features of construction. Its bottom-board is in all essentials similar to that of the hinged feeder, the only additions being a second truss to the strengthening bar, and the provision of a second lug, should the bellows have to be placed low and an overhead blowing action adopted. The under side of a complete bottom-board is shown in Fig. IV., Plate XIV. The strengthening bar A is extended at both ends to form the two lugs C, and is double-trussed at B. When the blowing action is placed under the bellows, it is attached to the center of the strengthening bar at A, and no lugs are required. As the bottom-board rises and falls parallel to the receiver, four pairs of direct ribs are required. These are shaped and chamfered, hinged with linen cloth, and jointed and gusseted with strong leather in the manner fully described for the direct ribs of the receiver, due regard being paid to the extra strength necessary for a feeder to be actuated by a motor.

When a large bellows is required, the receiver should, if practicable, be made square and have four whole-drop square feeders, the latter being actuated by vertical connecting-rods, bearing on the centers of their bottom-boards, and rising from the ends of rocking levers. These levers may be operated directly by the piston-rod of a water-motor, or from an automatically-controlled crank-shaft, turned by an electric motor or a gas-engine. It is perhaps unnecessary to state that the bellows, in this case, requires to be elevated sufficiently to allow the rocking levers and their vertical connecting-rods to be placed directly under the feeders, sufficient height being allowed for the mechanism to work properly, without straining the feeders. When whole-drop feeders are used, care must be taken to have large or numerous valves in the middle-board, to enable them to inject their wind freely into the receiver, because, as previously stated, they deliver at each upward stroke about double the volume of wind delivered by a hinged feeder of the same superficial measurement.

It is only necessary to allude to one other form of feeder of the bellows

class; namely, that known as the vertical double-action or compound feeder, designated by some writers on the Organ the French feeder. In its simplest form this appliance consists of two oblong feeders of the whole-drop pattern, the sucker-boards of which are fastened together with a free air-space of 3 or 4 inches between them, and the outer boards of which are fixed, and have wind-trunks attached to them, within which are the valves that admit the wind into them, but prevent its return to the feeders. The whole is placed vertically and operated by a horizontal action, commonly connected with the piston-rod of a water-motor. The action simply moves the joined sucker-boards to-and-fro between the outer stationary boards: one feeder charging itself from the air-space between the sucker-boards, and the other discharging its contents, through the valves in the stationary board, into the attached wind-trunk. In large appliances of this class each feeder is formed with two sets of direct ribs, properly furnished with a floating-frame held in position by parallel-action regulators. In all cases the movable parts of the feeders have to be supported so as to prevent the slightest drop or strain on the ribs. The common expedient is to attach small wheels to the ends of a bearer passing between, and firmly fixed to, the sucker-boards, and allowing them to run on horizontal bars of hardwood or iron. A supporting lever movement has been adopted in some cases with marked success. Vertical, double-action feeders, formed as above described, deliver large volumes of air without calling for a quick movement. This fact favors the adoption of a single cylinder water-motor, the stroke of which is equal to the to-and-fro motion of the sucker-boards.

MECHANICAL BLOWERS.

Under the term Mechanical Blowers are included all the machines or mechanical appliances which take the place of the feeders of the bellows form, such as those which have been described in the preceding pages. The introduction of mechanical blowers has done much to simplify the bellows equipment of large Organs; and it is not too much to believe that, so far as important instruments are concerned, the hinged, whole-drop, and vertical double-action feeders will before long be entirely abandoned. It is not to be wondered at that the first form of mechanical blower used by modern organ builders is the one suggested by the corresponding adjunct in the ancient Hydraulic Organ, which consisted, as far as can be gathered from ancient writers, of a cylindrical chamber, furnished with inlet- and outlet-valves, and having within it a movable piston or cylindrical plunger, which by its upward and downward motion alternately charged the feeder and the receiver of the Organ.

In German Organs blowers of this class have been frequently introduced. They are in the form of square chambers or boxes of wood, furnished with valves, and in which pistons of wood edged with leather, or box-like plungers of wood are moved by some simple lever action. When simply a blower, forcing wind into an independent receiver, the appliance is designated "Windpumpe";* but

* A carefully-detailed Section of a double-action blower of this class is given in "Die Orgel und ihr Bau," by Seidel & Kothe (Leipzig 1887), page 31. A Section showing a single-action blower of the same class (System

when it is both a feeder and receiver, on the principle of the old diagonal bellows, it is designated a "Kastenbalg."* Blowers for the delivery of wind at very high pressures have been constructed with metal cylinders and pistons, after the model of the cylinder and piston of the steam engine. In the simplest form the cylinder is furnished at each end with an inlet-valve to the open air and an outlet-valve into the wind-trunk. Between these pairs of valves the piston is moved by means of its rod, connected with some kind of driving engine or motor. In the most complete form, as patented by the late Mr. Henry Willis,† the cylinder has a large slide-valve attachment, which commands three oblong ports (similar to those of the steam-engine), and allows free air to enter through one end port, while it conducts the compressed air, issuing from the other end port, into the wind-trunk, through the middle port, and thence to the receiver. To prevent the necessity of stopping or slowing down the motion of the piston when the main receiver is full, or approaching its full expansion, another slide-valve attachment is provided, which forms a by-pass between both ends of the cylinder, preventing any wind being delivered to the receiver. This by-pass valve is actuated by the top-board of the receiver—opening and closing automatically. By this class of blower wind of any desirable pressure can be supplied. The appliance with its engine or motor is necessarily costly, and has to be placed at a considerable distance from the Organ, demanding at the same time expert attention.

Serious attempts have been made by some organ builders, especially in America, to introduce fan blowers, but there are certain insurmountable objections to their use, and these will prevent their adoption to any considerable extent. One objection is the high speed necessary to generate adequate wind-pressures; namely, two thousand revolutions and upwards per minute. The second, and perhaps still graver, objection is the very disagreeable noise or hum set up by such high speed, rendering it necessary to locate the fan at a great distance from the Organ, and in some place where its noise can be deadened as much as practicable. It must be realized that wherever the fan is placed, it must use wind of the same temperature as that which surrounds the Organ. The third objection is the expense incident to the use of a powerful fan. There are other minor objections, to which it is unnecessary to allude here.

We now have to speak of the latest, and in our opinion the most satisfactory, if not the only satisfactory, mechanical blower at present invented: we allude to "The Kinetic Blower," invented by Mr. Louis Bertram Cousans, of Lincoln, England.‡ Externally the appliance is in the form of a square box, from the sides of

Walcker), with all its valves and attachments, is given in "Die Orgel, ihre Geschichte und ihr Bau," by Otto Wangemann (Leipzig 1895), Fig. 49.

* Illustrations of "Kastenbälge" are given in "Die Theorie und Praxis des Orgelbaues," Plate XXVI., and in "Die Orgel und ihr Bau," page 24.

† "Supplying Air to Organs." English Letters Patent, No. 4820, dated December 18, 1887.

‡ We regret that we are unable to give an original disquisition on this admirable appliance; but although we requested full particulars and diagrams to enable us to write with some authority and clearness respecting it, we failed to get a proper response from The Kinetic-Swanton Company, of London, or its American representative. While we have inspected a Kinetic Blower in operation, and are satisfied with the efficiency claimed for it, we are compelled to refer to matter printed on it for the brief description we venture to give in our text. We may add that we have not had the privilege of inspecting the internal mechanism of the blower.

which other box-like portions project, the use of which we are not able to state. A shaft, actuated directly by an electric motor, enters the box, and carries within the box three or more fans of a peculiar form, which in revolving pass the wind onward, each successive fan increasing its pressure.* When in action the compressed air issues from the upper part of the box in a smooth continuous stream. In a blower fitted with several fans, the apparatus can be tapped at three or more places and winds of different pressures can be drawn for service in the different divisions of the Organ. This is an advantage no other mechanical blower possesses. The Kinetic Blower does not require to be run at a speed above one thousand revolutions per minute; and under ordinary favorable conditions only a very slight noise is created, so slight, indeed, that when the blower is removed a short distance from the Organ, and inclosed or placed in an adjoining chamber or room, it need not be considered. The wind-supply is under perfect control, being automatically governed by the rising and falling of the receiver. The consumption of the electric current, or of power, is directly proportional to the wind consumed. When the Organ is silent, hardly any power is used; and as it speaks with more or less strength of tone, more or less power is exercised by the motor. The Kinetic Blower can be belted directly from a suitable gas- or petrol-engine; but in all possible cases the electric motor should be adopted.

THE CONCUSSION-BELLOWS.

To counteract any sudden and temporary alterations of pressure in the organ-wind in its passage from the receiver to the wind-chest, resulting from unsteady blowing and other minor causes, an appliance was devised in the early part of the last century by Mr. Bishop, Organ Builder, of London. It was first used by him in the Organ he built for Covent Garden Theatre. This appliance, known as the Concussion-bellows, is extremely simple in construction and operation. In its most common form it consists of a small cuneiform bellows screwed air-tight to the side of the connecting wind-trunk, in which an opening has been cut for free communication. A bridge extends across the bellows, some distance from its outer or movable board, for the purpose of receiving the ends of two strong springs, which, held in position by the bridge, exert their pressure on the bellows and keep it at the point of half-expansion when the compressed air is in the wind-trunk. A Longitudinal Section of this simple appliance is given in Fig. CCCLXXXII. A is a portion of the wind-trunk; B the concussion-bellows; C the spring-bridge; and D one of the springs.

The operation of the appliance is as follows: When the wind-trunk is filled with the organ-wind from the receiver, and all is practically in a state of rest, the concussion-bellows is expanded by the pressure of the wind to about half its possible extent, the springs having been adjusted to allow that medium degree of

* The blowing apparatus installed in Worcester Cathedral is "composed of two electric motors of 8½ and 3½ horse power respectively, direct current 460 volts, coupled, without the intervention of belts or other gearing, to a Kinetic Blower; the larger being capable of delivering 2,500 cubic feet of wind at 15 inches pressure, the smaller receiving 1,150 cubic feet of this wind and raising it to 23 inches pressure."

expansion at the normal pressure of the organ-wind. So long as the wind remains steady the concussion-bellows does not move from this point of expansion; but on the slightest alteration of its pressure, caused by unsteady blowing, or any sudden and extreme demand, or any sudden stoppage of that demand, on the wind passing through the wind-trunk, the concussion-bellows either becomes less or more expanded—pressing its contents into the trunk to counteract any temporary reduction of pressure, or receiving from the trunk any surplus wind created by a sudden increase in the pressure of its column. Any spasmodic action of the wind, which might disturb the intonation of the pipe-work, is, accordingly, almost entirely neutralized by this automatic action of the concussion-bellows.

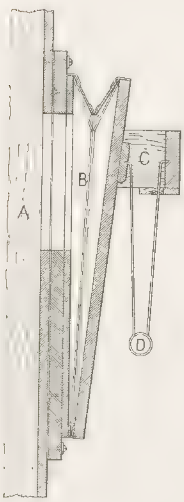


Fig. CCCLXXXII.

Concussion-bellows are frequently made with eight direct ribs, and have a parallel action. These are more efficient than the cuneiform, and are specially suitable for horizontal wind-trunks. Both forms of the appliance require careful adjustment to suit the peculiar conditions of the Organ in which they are inserted; and nothing but a series of tests can be depended on to secure satisfactory results. Carelessly-made and imperfectly-adjusted concussion-bellows will invariably do more harm than good; and such have frequently been removed, or rendered impotent by being screwed down.

Concussion-bellows have been found of service for steadying the wind furnished to certain classes of pneumatic actions, notably those in which the pneumatic lever is introduced. An example of this application is furnished by the Concert-room Organ in the Town Hall of Manchester, built by the late M. A. Cavaillé-Coll. In this instrument there are no fewer than eight concussion-bellows—two for steadying the general organ-wind, and six for the wind operating the pneumatic key and draw-stop actions. This Organ affords an eloquent proof of the value of the concussion-bellows when scientifically made, proportioned, and adjusted. It also shows the estimation in which it was held by the most distinguished and talented organ-builder France has ever produced.

There is one matter in connection with the concussion-bellows which must be noted; namely, that it must not be applied in an uncontrollable condition to a wind-trunk with which a tremolant is in any way connected. The reason for this is obvious; for while the latter appliance is introduced for the purpose of imparting a rhythmical disturbance to the wind furnished to the pipe-work, the concussion-bellows is introduced for the purpose of neutralizing or counteracting all possible disturbances of that wind. It is, accordingly, necessary when both a tremolant and a concussion-bellows are attached to any division of an Organ, to provide some automatic contrivance by means of which the action of the latter is arrested at the instant the tremolant is set in motion, and released when the tremolant is stopped. An ingenious pneumatic action for accomplishing this is to

be seen in the Organ in Glasgow Cathedral, built by the late Henry Willis, of London.

In the preceding remarks we have spoken of the concussion-bellows as attached to the wind-trunk only; but in some instances it has been placed immediately beneath the pallet-box of the wind-chest, under the impression that it would, in that position, have a more direct influence on the pipe-wind. Of its efficiency in this direction we have been able to obtain no reliable reports. The concussion-bellows was introduced for the purpose of counteracting the objectionable effects of imperfect hand-blowing, and in that direction it undoubtedly did good service; but with the more satisfactory methods of mechanical blowing, it is very questionable if its presence in the economy of the Organ is necessary or desirable. It can certainly be dispensed with when, in conjunction with such blowing, the bellows, wind-trunks, and wind-chest are of ample dimensions and capable of meeting all demands that can be made upon them.

WIND-TRUNKS AND CONVEYANCES.

Having in the preceding pages described the bellows and its adjuncts, by means of which the organ-wind is collected, compressed, and stored for instant use, we may conclude the present Chapter by adding a few remarks respecting the parts of the Organ whereby the compressed wind is conveyed, in its proper condition, from the main bellows to the reservoirs or wind-chests, or from any one part of an Organ to another. These wind-conduits when of large dimensions are called *Wind-trunks*, and when of small size are known as *Conveyances*. The wind-trunks which are introduced in the interior of the Organ, or which convey the compressed air from a bellows or feeder located in its immediate vicinity, are almost invariably in the form of quadrangular tubes of wood; but in modern Organs which have their bellows or feeders located at a considerable distance, cylindrical metallic wind-trunks are frequently and wisely used. An admirable example of this latter form is furnished by the bellows arrangement of the Organ in Westminster Abbey. In some few cases where the wind-trunk has to pass from one part of a building to another underground the wind-trunks are formed of glazed stoneware drain-pipes, carefully laid, and closely jointed with damp-proof cement. An example of this method obtains in the Cathedral of Manchester.

All wind-trunks of wood are formed of four boards, cleanly dressed, and put together in the strongest and tightest manner. The best form, in cross section, is square; for not only is it the most economical in material in proportion to the amount of wind it conveys, but it allows the largest column to pass through it with the minimum amount of friction. Great attention must be paid to the manner in which wooden wind-trunks are bent or mitered; all abrupt angles are to be avoided, for they seriously check the rapid flow of the wind and create unsteadiness in certain styles of playing.

When the receiver is large and the feeder action is uniform and steady, it may be accepted as a general rule that the wind-trunks can neither be too capacious, reasonably speaking, nor too direct in their run. To secure the advantages of large

area in cross section and the shortest possible passage for the wind from a receiver or reservoir, a special collapsible, quadrangular trunk has been devised, called the *accordion wind-trunk*. This is formed of several narrow ribs of thick cardboard hinged together and gusseted with thin, strained sheepskin and attached to two flanges or frames of wood whereby it is secured to the receiver, etc. A section of a small portion of an accordion wind-trunk is shown at H in Fig. CCCLXXVIII. This form of wind-trunk was largely used by the late M. Cavaillé-Coll in his important Organs. When reservoirs, weighted to yield winds of different pressures, are supplied from a main receiver and from each other, they are most conveniently placed, in a series, directly over each other and connected with accordion trunks, furnished with automatic supply-valves as represented in Fig. CCCLXXVIII.*

In large and complicated Organs it has been found expedient to insert valves in certain wind-trunks, commonly called wind-trunk ventils, to enable the performer, by means of some suitable lever or pneumatic actions, to admit or cut off the wind-supply belonging to certain divisions or sub-divisions of the pipe-work. The wind-trunk ventil is simply a valve or pallet placed within the trunk in such a manner as to effectually and instantaneously open or close its wind-passage. The valve assumes several forms according to the dimensions of the trunk, the position it occupies therein, and the motive power employed in operating it. Care must be taken to so construct and mount the valve that when open it will to no serious extent diminish the wind-way. A small relief-valve should be provided which will open as the wind-trunk ventil closes, so that the compressed air in the portion of the trunk cut off may escape, and prevent any lingering effect on the pipe-work.

Conveyances are practically diminutive wind-trunks, used for conveying small streams of compressed air or organ-wind from one portion of the Organ to another; to furnish wind to the numerous appliances connected with pneumatic actions; and to convey organ-wind from wind-chests to the feet of pipes planted at some distance from the chests. Conveyances of small size are properly made of good, stiff pipe-metal, rounded, and soldered like a pipe-body. When larger than 1 inch in diameter, they are commonly made of zinc. Certain American organ builders have of late years used conveyances made of rolled pasteboard or thick paper. These are seldom less than 2 inches in diameter. When well protected inside with shellac varnish, and outside with paint, these pasteboard conveyances leave little to be desired. They are strong, light, and durable. Great care must be observed in mitering conveyances so as not to interfere with the easy flow of the wind within them.

A long Chapter could be written on the several more or less important details connected with wind-trunks and conveyances; but as such details are largely controlled by ever-changing circumstances and conditions, and as our space is very valuable, we have considered it unnecessary to enlarge on the subject.

* An illustration showing a series of four superposed reservoirs directly over a receiver, all connected by accordion trunks, is given in "Die Orgel und ihr Bau" (Leipzig 1887), page 29.

CHAPTER XLVI.

ELECTRICITY IN ORGAN-BUILDING.

IN the present electrical age it is quite to be expected that considerable interest should be taken in electricity as a means of transmission of movement in the key, draw-stop, and other actions of the Organ; and, unquestionably, great strides have been made in this direction since the inception of the electro-magnetic action. But, notwithstanding all that has been achieved by a host of accomplished electricians and skilful and ingenious organ builders, there remain the objectionable elements of uncertainty and unreliability—evidenced in the most unexpected directions, and invariably at the most critical moments—that dispose one to look with more favor on other forms of action, especially in cases where those forms are clearly available and can be effectively employed. Notwithstanding what has been done, and after a careful and dispassionate investigation of all the more important electro-pneumatic systems at present used, we can with perfect assurance advise the rejection of all such systems for Organs that can be satisfactorily constructed on the most approved tubular-pneumatic systems. Let electricity be resorted to when, and only when, its use is imperative; namely, when the Organ has to be placed at a considerable distance from, and in an inconvenient relation to, the controlling console; or when a movable console is absolutely necessary. It is to be taken for granted that no organ builder who has devised, or who uses, an electro-pneumatic system, will admit for a moment that it is or can be found unreliable. To get at the true facts one has to listen to the sad experiences of long-suffering organists. That electro-pneumatic actions are uncertain and unreliable cannot be wondered at when one realizes the many hundreds of contacts and delicate movements which belong to such actions, and the very many and extremely slight causes which at any instant may cripple them. Yet, after all, it must be conceded that an electro-pneumatic action scientifically installed, in which all the contacts are so formed and of such a metal as to keep clean and free from oxidation, in which electro-magnets of high resistance are employed, and in which

the pneumatic action gives the magnets very little work to do, will, with proper and skilled attention and care, be found fairly, if not constantly, satisfactory from the performer's point of view. Any derangements which may from time to time occur, while they are extremely distressing to the performer, are usually local and easily rectified by an experienced hand.

In whose brain the idea of employing electric force in organ mechanism first took form is a question that has never been decided.* On the authority of existing records, the first person to give definite form to the electro-magnetic action (as distinct from the electro-pneumatic action) was Henry John Gauntlett, Mus. Doc., of London; but it is doubtful if the inception of the action is due to him. In the year 1852 Dr. Gauntlett took out a patent for this electro-magnetic action;† and to clearly lay his claims before the reader, we give the following extract from the Specification:

"This Invention has reference,—Firstly, to a mode of simplifying the construction of finger and pedal organs by avoiding the necessity for the complete mechanism heretofore required for transmitting the movement of the keys or the pedals of organs to the pallets or valves which admit the wind from the wind-chest to the various pipes. In carrying out this part of my Invention I establish an electric circuit between the pallets and the keys and pedals respectively, and by transmitting an electric current on the depression of a key to a bar of soft iron (forming a temporary magnet) in connection with the pallet which is required to be opened, a sufficient motive power is obtained to open the pallet or valve, and produce the note required to be sounded without the intervention of rollers, backfalls, squares, &c., at present used. By this means I also avoid the deep fall of the key, and the heavy pressure therefrom, characteristics which render the organ difficult to play, and are unfavorable to perfection of mechanism and expression in the handling and execution of rapid and difficult music. The arrangement of the apparatus for conveying and applying the electric current may be varied as circumstances may require.

"This means of communicating motion to parts of organs I also propose to apply for drawing and shutting off the stops, for coupling them with any two or more of the key-boards, or with the pedals, throwing them out of connection, and likewise for working the shutters of the swell-box, and by this means I avoid the necessity for the use of the complex mechanism heretofore employed for effecting these several objects."‡

The system patented by Dr. Gauntlett is strictly an electro-magnetic one, for no use is made of a pneumatic auxiliary, and herein lay its complete failure from a practical point of view. His magnets are placed within the pallet-box of the wind-chest, and act directly on iron armatures attached to the free ends of the pallets.

* During the discussion which followed the reading of Mr. Henry Bryceson's Paper on the Electric Organ, before The Society of Arts, on December 25th, 1868, Mr. Forster, Organ Builder, of Hull, stated, without qualification, that "the late Herr Schulze, the clever organ builder at Paulinzelle, was the first to apply electricity to Organs." No absolute proof was given in support of this statement by Mr. Forster, and we have been unable to find any.

† English Letters Patent, No. 14,222. Dated July 15, 1852. (A communication.)

‡ It appears that Dr. Gauntlett contemplated the application of electric force to the Organ some time prior to his Patent. The following remarks appeared in *The Orchestra* of March 28, 1868: "The using of electricity as a motive power in organ-building was first mooted about twenty years ago [say 1848] by Dr. Gauntlett, who at the time of the Great Exhibition of 1851 proposed a scheme for playing all the Organs in the place at one and the same time."

Under this arrangement the magnets have to be sufficiently powerful to pull open the pallets against the combined pressure of the organ-wind and their recovering springs. Dr. Gauntlett made a great mistake in not using some pneumatic motor in conjunction with his electro-magnet, and thereby rendering a large and very powerful magnet unnecessary.

In our hurried historical review we have to leave England for a time, and direct attention to the work of the French organist and expert, Dr. Albert Peschard. Some time prior to the year 1861, and while organist of the Church of Saint-Étienne, at Caen, Dr. Peschard tried some experiments in connection with electricity applied to organ-mechanism, but what these were, or with what results, is not clearly known. In the year 1861 he fortunately formed a collaboration with

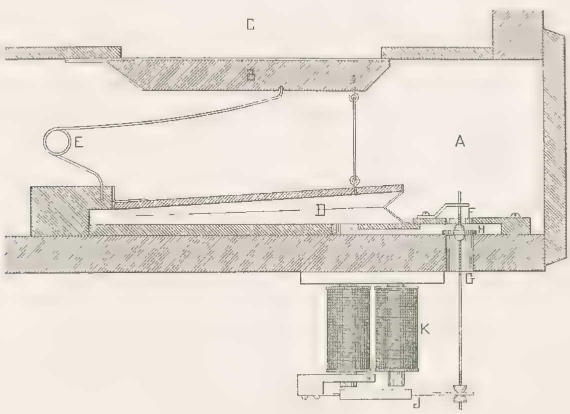


Fig. CCCLXXXIII.

Mr. Charles Spackman Barker, the English organ builder of pneumatic-lever fame, which ultimately led to satisfactory results. Dr. Peschard took out patents in 1863, but these may be passed over as unimportant in comparison with his patent of 1864. In this last patent is set forth for the first time in the annals of the organ builder's art the principle on which all subsequent electro-pneumatic actions are founded which operate the pallets of the ordinary pallet and slider wind-chest. To clearly show this to be the case we give in Fig. CCCLXXXIII. an exact reproduction (reduced) of the drawing given in Dr. Peschard's work, "Les Premières Applications de l'Électricité aux Grandes Orgues" (Paris, 1890). The appliance is extremely simple. A is the pallet-box of the wind-chest, in which the pallet B, commanding the groove C, is linked to the small bellows D. The pallet is held against its seat and the bellows is expanded, in the manner shown, by the pallet-spring E. The interior of the bellows is in communication with the interior of the pallet-box through the circular opening F and the channel leading therefrom, and with the external air through the lower opening G. Between these

openings the small disc-valve H rises and falls according to the motion of the armature J to and from the poles of the electro-magnet K. When the action is at rest, as indicated, the compressed air or pipe-wind fills the motor-bellows D, allowing the pallet-spring to keep the pallet closed. Now, when the electric current is allowed to excite the magnet, the armature is attracted, the disc-valve closes the opening F, and uncovers the opening G. The bellows D instantly collapses under the pressure of the pipe-wind in the pallet-box, and opens the pallet B. When the electric current is broken on the release of the manual key, the bellows is again filled with the pipe-wind, and the pallet is closed by its spring. Before continuing our notes on the Peschard-Barker collaboration, and with the desire to pay some attention to chronology, we may state that in 1863 Mr. John Wesley Goundry took out a patent for an electro-magnetic action.* The following digest of his system, as printed in the "Abridgments of Specifications relating to Musical Instruments;" cannot fail to be interesting to the student of the art of organ-building:

"'Improvements in Musical Instruments;' namely 'the application of electro-motive power to Organs and other similar keyboard instruments, whereby the ordinary movements may be entirely superseded,' and 'the reducing the inharmonic system to the simplicity of the ordinary keyboard, preserving at the same time the required facilities for modulation.' The patentee allows that the application of electro-magnets to organ-pallets is not new, but affirms that the amount of resistance offered to the action of the magnet, however, sufficiently accounts for the failure of previous attempts.' He mentions the different sorts of [relief] pallets in use, and describes his method of connecting a magnet to each sort so as to reduce the resistance as much as possible, adding that his arrangements may be varied as occasion may require. 'The contact connections at the finger keys may be either mercurial or by pressure of springs, or a combination of the two methods, and the keyboard may be at any desired distance from the instrument, provided the battery is sufficiently powerful to cause the current to traverse the additional length of wire.' . . . He describes at length several other improvements in the working of Organs by electro-magnetism:—1, 'a method of coupling without adding to the weight of the finger key;' 2, 'the application of an electro-magnet to wind-valves communicating with pneumatic bellows used to actuate the stop-slides or any other part requiring considerable power or leverage, as the ordinary composition [combination] pedals;' 3, 'the arrangement of the stop-slides;' 4, 'the manner of arranging the contact-plates for the universal pedal;' and 5, 'the introduction of a melody coupler.'"

It will be seen from the above that Mr. Goundry's electro-magnetic action is a slight improvement on that patented by Dr. Gauntlett, his electro-magnets acting directly on relief pallets instead of on ordinary solid ones used by Dr. Gauntlett. The pneumatic lever is, however, mentioned, and a form given for its application.

The Peschard-Barker collaboration bore actual fruit in 1866, when the first electro-pneumatic Organ constructed in complete form was erected at Salon (Bouches-du-Rhône).† The second electro-pneumatic Organ constructed on the

* "Improvements in Musical Instruments." English Letters Patent, No. 2940. Dated October 10, 1863.

† "L'inauguration de l'orgue électrique de Salon eut lieu en 1866. Le succès pour le début fut complet, et, aujourd'hui, après vingt-quatre ans de service, cet instrument, possédant deux claviers à main, clavier de pédale et accouplements ordinaires, fonctionne encore avec une régularité irréprochable. M. Payan qui le joue

Peschard-Barker system was erected in the Church of Saint-Augustin, Paris, and inaugurated in 1868. As early as 1863 the electro-pneumatic system was approved of for this important Organ by the Commission appointed by the Government. The Commission comprised MM. Dumas, Baltard, Ambroise Thomas, Batiste, du Moncel, Lissajous, and Seguier. The Organ was constructed by Barker. Another important electro-pneumatic Organ by the same builder was erected at Montrouge immediately after that of Saint-Augustin, which is said to have contained some improvements. This instrument was destroyed during the siege of Paris in 1871.

The exact nature of the electro-pneumatic action used by Barker for the Organs of the Church of Saint-Augustin and at Montrouge can be gathered from the Specification of the patent he took out in England in 1868.* In the preamble of the Specification, Mr. Barker says:

> "By the use of this Invention the construction of large instruments is considerably simplified, and the frequent derangement of the key and draw-stop actions is avoided. Great facilities are also afforded for placing the keyboards at any required distance from the instruments, and a light and uniform touch is secured.†
>
> "To carry out the above objects with respect to the key action I establish beneath the several wind-chests of a large Organ an arrangement of pneumatic levers worked by electro-magnetic apparatus, which arrangement is capable of easy detachment from the wind-chest for the purpose of repairs. Immediately under each pallet of the several wind-chests and connected therewith is a small power-bellows or pneumatic lever, which upon being inflated draws and maintains open the pallet connected therewith, but when in a state of collapse allows the pallet to close. The inflation of the bellows is obtained by the introduction of compressed air from an air-trunk communicating therewith, and its collapse is caused by cutting off the connection with the air-trunk and allowing the air in the bellows to escape into the atmosphere. The inflation and exhaustion of the bellows are determined by the relative position of a suitable valve brought into play by the action of an electro-magnet. The coiled wire of the electro-magnet forms part of an interrupted electric circuit which terminates at the opposite poles of a voltaic battery or other generator of dynamic electricity. The circuit extends to the keyboards, and is susceptible of being completed by means of certain metallic appendages brought into contact by the depression of the keys."

It will be realized from the above brief description that the action patented by Mr. Barker differed but little in arrangement and not at all in general principle from that patented four years earlier by Dr. Peschard, as illustrated in Fig. CCCLXXXIII. The only difference of any importance lies in the position of the power-bellows connected with and acting on the pallets. In the Barker patent they are placed outside and underneath the wind-chest, the pull-down wires passing through old-fashioned leather purses on their way to the pallets. The

depuis sa réception m'affirme même que, pour ce qui concerne la partie électrique, il paraît aussi neuf qu'au premier jour." "Les Premières Applications de l'Électricité aux Grandes Orgues." Paris 1890.

The above is a remarkable tribute to the genius and skill of Messrs. Peschard and Barker: the Organ was built by the latter.

* "Improvements in the Construction of Organs." English Letters Patent, No. 232. Dated Jan. 22, 1868.

† It must be borne in mind, in reading the comparisons instituted in the descriptions of all early electro-magnetic and electro-pneumatic actions, that the ordinary old tracker action is alluded to as being superseded.

electro-magnets hang downward, as in the Peschard patent, attract a horizontal armature, and actuate twin disc-valves. The chief advantage of the Barker appliance over the earlier one seems to obtain in the attachment of all the power-bellows or pneumatic levers, the electro-magnets, and the controlling disc-valves, to a horizontal table which is simply clamped to the under surface of the wind-chest. On unscrewing the lower buttons of the pull-down wires, the table with everything attached to it can be easily removed "for the purpose of repairs." The manner in which the circuit is completed at the claviers is thus described by Mr. Barker in the Specification:

"Each key is connected in the usual way with a backfall or rock-lever, and these levers are fitted at their free end with insulated plates carrying each two points. Immediately below these points are situated mercury cups formed in a transverse plank and arranged in two rows. Through one row runs a wire which connects with one pole of the battery, and projecting through the plank into the cups of the other row are metal screws which carry each an electric wire, which is led off to an electro-magnet. The depression of a key causes the metallic points carried by the backfall to dip into their respective mercury cups, and thus electric conduction is set up between them. The current will then flow from the battery through the cups, and by the wire leading therefrom to the electro-magnet which commands the pallet or pallets of the pipe or pipes corresponding to the key depressed and the note desired to be sounded. As soon, however, as the pressure of the player's finger is removed from the key the electric contact will be broken and the pipe or pipes will cease to speak. From the above explanation it will be understood that for each note in the compass of the Organ there is an electro-magnet provided which is operated through its corresponding key to produce the sound or sounds corresponding in name to the key depressed by the performer."

In the Specification a description is given of an electro-pneumatic draw-stop appliance, in which two power-bellows, linked together, and commanded by an electro-magnet and a small primary pneumatic are employed to move the slider of the wind-chest. An ingenious method of saving waste of the elements composing the battery is also given. "The jars carrying the solution are mounted on bellows, which being inflated when the Organ is in use will cause the jars to rise and virtually plunge the electrodes into the solution, the electrodes being secured to a fixed bar. When the Organ ceases to be supplied with wind, the bellows will collapse and leave the electrodes suspended in the air and free of the destructive action of the solution."

We now come to the introduction of the electro-pneumatic Organ into England. This was done by Messrs. Bryceson Brothers and Morten, Organ Builders, of London, who purchased the right to use Mr. Barker's patent immediately on its completion in January, 1868. These distinguished builders were at the outset dissatisfied with the somewhat cumbersome and primitive character of Mr. Barker's system, and in April of the same year took out a patent for certain radical improvements,* which are thus summarized in the preamble of their Specification:

* Improvements in the Construction of Organs and in the Application of Electricity thereto." English Letters Patent, No. 1149, dated April 6, 1868. Fully and well illustrated.

"These improvements refer to a special construction of sound-board pallets to be used either with an electric or mechanical key, or pedal action, whereby a perfectly light touch is obtained without the aid of an additional or intermediate power-bellows. Also a special combination and arrangement of pneumatic power-bellows and electro-magnets for working the sound-board slides by which much complicated mechanism is avoided. Also a special arrangement of contacts for electric combination movements of the stops. The pallet [the leading feature of the system] is a diagonal bellows consisting of top- and bottom-boards and ribs. The upper side of the top-board is covered with soft leather, and forms a valve bedding close on the sound-board bars. It is kept in this position when at rest by a spring pushing from the bottom-board. The back end of the bottom-board is fitted into a hole in the wind-bar provided for it, and has a groove through it communicating with the interior of the bellows. The front end of the bottom-board is fixed sufficiently far below the top-board as to distend the ribs to their full extent. The principle of opening this pallet is that when an exhaust is created in the interior of the bellows the top-board will be drawn down, and allow the compressed air which is around it to pass into the sound-board groove to the pipes placed in communication with it. The pressure of the compressed air in the well [pallet-box] of the sound-board on the ribs of the bellows is alone under certain circumstances sufficient to pull the top-board from the sound-board bar, on the air contained in the bellows being allowed to escape. To close the pallet the exhaust is stopped, and the compressed air from the well of the sound-board is allowed to enter the bellows, which immediately raises the top-board to its original position against the sound-bar. The inflation and exhaustion of the bellows is determined by the relative position of a double-action valve brought into action either by an electro-magnet or any of the known mechanical movements used to communicate the motion of the key to the usual pallets of the sound-board."

Under the arrangement of parts adopted by Messrs. Bryceson Brothers and Morten, the electro-magnets are the only ones located under and outside the wind-chest, and these are protected from dust and injury by being inclosed in a light casing. Of the appliance for drawing the sliders of the wind-chest it is unnecessary to speak in this brief review.*

All the actions previously spoken of are radically imperfect, chiefly because they call for too much work to be done by the electro-magnets. Even in the Barker and Bryceson systems, the electro-magnets had to move somewhat heavy, hinged, iron armatures, which in turn had to lift valve-stems and disc-valves against the pressure of the organ-wind contained in the valve-chambers. Not only were such large and powerful electro-magnets cumbersome and costly in themselves, but they called for large and expensive batteries, difficult to maintain in proper working order. The systems of key-contacts adopted proved very unreliable. That the Peschard, Barker, and Bryceson systems did the work reasonably claimed for them may be granted; but, nevertheless, they were purely tentative and radically imperfect, as will at the present day be readily conceded.

Confining our review for the present to the systems which embrace the pallet and slider wind-chest, and passing over some improvements of minor importance, we may pass on to the electro-pneumatic action patented by Messrs. Schmoele and Mols in 1881, and which has been used with fair success by Messrs. Merklin

* The reader who desires further information regarding the electro-pneumatic action patented by Messrs. Bryceson Brothers and Morten will find a full description in "The Organ," by Hopkins and Rimbault (London 1870), pp. 77-87. Fully illustrated.

and Company, of Paris, in the Organs constructed by them for the Church of Sainte-Clotilde, Paris, in 1888; the Church of Saint-Vincent-de-Paul, Marseilles, in 1889; and the Cathedral of Notre-Dame, Paris, in 1890. We have before us as we write an electro-pneumatic lever, similar to those used in the Organs just alluded to, which Mr. Merklin presented to us while we inspected the Choir Organ of Notre-Dame under his guidance in the year 1891.

In the appliance invented by Messrs. Schmoele and Mols a successful attempt is made to reduce the size of, and the work to be done by, the electro-magnet. The magnet is tubular, one limb or pole being open, so as to allow the compressed air in the pallet-box to pass through it into a small chamber covered with a thin leather diaphragm, formed in the woodwork of the lever. The under side of this diaphragm is in constant contact with the compressed air in the pallet-box. Suspended from the diaphragm is a light disc-valve, which commands two openings: one admitting the compressed air to the interior of the associated power-bellows, and the other placing the interior of the power-bellows in communication with the open air. The armature is a strip of very thin soft iron, about 1½ inches long by ½ inch wide, covered on both its faces with thin silk, the free ends of which form the hinge. On the free end of the armature, where it comes in contact with the open pole of the magnet, is glued a small disc of paper; and underneath the end of the armature is glued a corresponding disc of soft leather, which commands a small hole in a metallic nipple screwed through the bottom of the pallet-box. The opening in this nipple places the channel in which the armature is suspended or hinged and the small diaphragm-chamber in communication with the open air. The power-bellows is of the usual hinged form, such as is shown in Fig. CCCLXXXIII., and is linked to the wind-chest pallet, and is pulled open by the action of the pallet-spring in the manner indicated in that illustration. When the appliance is at rest the compressed air fills the diaphragm-chamber and the power-bellows, while it presses the armature on the nipple and the disc-valve on the duct to the open air. When the electric circuit is completed at the key-contact, the electro-magnet attracts the armature, closes the opening in its own pole, and uncovers the opening in the nipple. The diaphragm-chamber exhausts through the nipple, the diaphragm is forced upward by the compressed air, and the disc-valve closes the opening to the pallet-box, and uncovers the opening to the atmosphere. The power-bellows exhausts into the open air, collapses under the pressure of the compressed air, and opens the wind-chest pallet, giving speech to the pipe-work. From this brief description it will be seen that the appliance is located entirely within the pallet-box, safe from injury and dust; that in its construction a primary and a secondary pneumatic are associated; and that the electro-magnet has only to lift a very light armature, on which the compressed air exerts a pressure on a surface about ⅛ inch diameter only—that immediately over the small nipple.* It is, perhaps, unnecessary to remark that electro-pneumatic levers constructed on the same principle were used by Messrs. Merklin for all the other movements of their

* Drawings (not absolutely perfect) of the appliance will be found in "Die Theorie und Praxis des Orgelbaues," Plate XLIV., Figs. 1 and 2. A more accurate drawing appears in "Organ Construction," by Dr. J. W. Hinton (London 1900), Plate X. This is accompanied by a full description.

Organs. In their installations they used friction contacts, for the manual and pedal claviers, formed of flexible wires and plates of *maillechort* (German silver).

Having explained the principles on which electro-pneumatic levers or motors have been constructed for the purpose of actuating the pallets of slider wind-chests of ordinary construction, we may now briefly consider the representative methods in which electro-magnetic force has been utilized in connection with pneumatic ventil wind-chests, without the intervention of pneumatic levers or power-bellows. Foremost among these methods is that applied by the late Mr. Hilborne L. Roosevelt to his pneumatic ventil wind-chest, illustrations of which are given in Figs. CCXII. and CCXIII. (Vol. II., pages 325 and 327). We may properly introduce this subject by quoting Mr. Hilborne L. Roosevelt's remarks on his patent electric action, written in 1883:

"In exceptional cases, when distance or awkward position of main site renders such a course advisable, we have employed Electricity in lieu of the ordinary action with eminently satisfactory results. One of the most successful instances is to be met with at Grace Church, New York City, where the old Organ in the western gallery and an Echo Organ in the roof are both connected with the new Organ at the east end of the church, all being controlled by one set of keyboards placed in the chancel. A distance of one hundred and fifty feet separates these Organs from each other, and *upwards of twenty miles* of electric wire are used, yet the response is instantaneous in every instance [erected in 1878]. We have also introduced it with equal success in the gigantic instrument built [in 1879–1883] for the Cathedral of the Incarnation, Garden City, L. I., as well as in the Concert Organ erected by us in Chickering Hall, New York City, and the Organ in the Congregational Church, Great Barrington, Mass. [Erected in 1883. Case designed by G. A. Audsley].

"Another instance of its practical utility was afforded by our Organ, built for, and used in connection with, the great May Festivals, held in New York and Chicago in May, 1882, the organist being enabled to sit immediately in front of the conductor, although the instrument was placed in a comparatively remote locality underneath the rear portion of the stage, where sufficient height was available. The use of this action also enabled us to take the instrument down in New York, remove it to, and re-erect it in, Chicago within the space of three weeks.

"Our method of applying this valuable agent differs essentially from that of others in one important particular. We do not employ the fluid as a motive power to open the main pallets, but simply as a transmitting medium by whose agency an *extremely small valve* is controlled, which in its turn, through pneumatic multiplication, effects the opening of the wind-chest pallets irrespective of their size and resistance. Although seemingly improbable, this operation is accomplished instantaneously, and it is impossible to detect any hiatus between the depression of the key and the production of its resultant sound, other than that caused by the inevitable acoustic delay in transmission of the vibrations from their distant source. When applied in this manner, the Electric Action will maintain its efficiency unimpaired by varied atmospheric conditions, and the cost of its maintenance does not involve increased expenditure, as compared with that of the ordinary mechanism."

Having fully described and illustrated the Roosevelt pneumatic ventil wind-chest in Chapter XXIX., it is only necessary in this place to give particulars of the manner in which the electro-pneumatic action is applied to the same. The electro-magnet with its associated small primary valves complete is shown in the accompanying illustration, Fig. CCCLXXXIV. M is the magnet formed of a

single bar of soft iron wound in the usual manner with insulated copper wire. C is the soft iron armature, pivoted within an opening at O in the bent supporting bar D. The shorter arm of the armature is drawn downward by the small, adjustable spiral spring L, the manner in which its strength is adjusted being indicated at N. All that this spring has to do is to support the weight of the longer arm of the armature, the valve-stem E, with the button F, the disc-valve G, and the small conical leather valve H. In the Side View the appliance is shown as at rest, with the disc-valve closing the lower end of the vertical tube K, and the conical valve H slightly lifted above the upper end of the tube. In the Section A—B the armature is shown attracted by the magnet, and the positions of the two valves reversed. On the armature at C is cemented a disc of thin cardboard to prevent actual contact of the armature and magnet. The appliance is screwed to the under side of a thick plank, the upper surface of which is indicated by the dotted line P. A transverse hole is bored in the plank at J, communicating directly with the perforation I in the tube K. The other end of the hole J opens into a bellows-pneumatic about $1\frac{1}{2}$ inches square, the inflation of which extends only about $\frac{3}{16}$ inch. From the center of the movable top-board of this pneumatic rises a wire valve-stem carrying the twin disc-valves of the wind-chest, shown at O and P in Fig. CCXII. (page 325). Immediately over the tube K, Fig. CCCLXXXIV., and on the top surface of the plank P is placed a longitudinal chamber, which is constantly charged with compressed air while the Organ is in use. The action of the appliance is as follows: When at rest, the compressed air in the longitudinal chamber enters the tube K, through the space left by the lifted valve H, and passes thence through the hole J into the small bellows-pneumatic, expanding the same, and raising the twin valves of the wind-chest to the position shown in Fig. CCXII. Now, on the depression of the corresponding manual key a contact is made, the magnet is excited, the armature is drawn down, the disc-valve G opens the lower orifice of the tube K, and the valve H closes the upper orifice. The bellows-pneumatic collapses under the united weight of its top-board, valve-stem, and disc-valves, and the pressure of the organ-wind on the valves at the wind-chest, the compressed air in the pneumatic exhausting into the open air through the lower orifice of the tube K. On the release of the key, everything instantly resumes its normal condition of rest as above described. This action in combination with the Roosevelt pneumatic wind-chest was unquestionably the greatest step in advance that had been made up to the time of its invention. It is quite easy to realize how the same appliance could be utilized throughout all the other movements of an Organ.

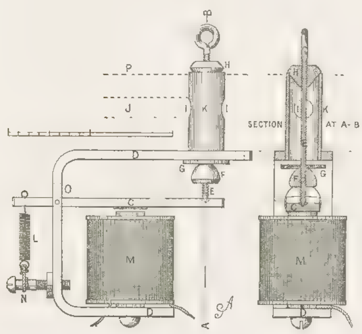


Fig. CCCLXXXIV.

Another form of electro-magnet was invented by Mr. Hilborne L. Roosevelt,

and patented after his death by his executor.* In this clever invention all the complication of levers, springs and external valves is done away with. The electro-magnet has an adjustable tubular core through which the compressed air can pass; below this is a cylindrical valve-armature adapted to enter partly within the coils of the magnet. This armature is smaller than the portion of the magnet in which it enters, allowing the compressed air to flow freely around it. Below the armature is an adjustable valve-seat, perforated so as to establish communication with the open air. When the magnet is not excited, the armature closes the opening of the valve-seat and allows compressed air to enter through the core of the magnet and find its way to the small bellows-pneumatic, which actuates the twin disc-valves of the wind-chest (in the manner previously described): but when the magnet is excited, the cylindrical armature is drawn up against the tubular core, stopping the supply of compressed air, and placing the interior of the bellows-pneumatic in communication with the open air. In the patent Specification the appliance is shown in two forms, in one of which the cylindrical valve-armature is placed vertically and operated by the magnet and gravity, and in the other of which it is placed horizontally and operated by two magnets.

The next most important departure in connection with the pneumatic ventil wind-chest is also due to American ingenuity. In 1900 Mr. W. B. Fleming, Organ Builder, took out a patent for a "combined electrical and tubular organ-action."† We can, however, pass over the details of this invention to those of a more advanced form of electro-pneumatic action, which operates the pouch-pneumatic wind-chest of the same inventor. Owing to Mr. Fleming's courtesy in furnishing us with a full-size model and the patent Specification of his perfected action we are enabled to give an accurate drawing of it on Plate XV., and the following description. For a full description and illustrations of Mr. Fleming's patent pouch-pneumatic wind-chest we refer the reader to pages 348-352 of the present volume.

The drawing on Plate XV. is a Transverse Section through the valve-box of the electro-pneumatic action, and through a portion of one of the stop-chambers and a pouch-pneumatic. The electro-pneumatic action may be described as follows: A is the interior of the valve-box, and B is the interior of the superposed chamber which contains the electro-magnets, one of which is indicated at M. Both these chambers are constantly charged with compressed air when the Organ is in use. Directly under the poles of the magnet M is a small iron disc armature, which, when the appliance is not active, rests upon the metal nipple which forms the entrance to the exhaust-duct 1, and which uncovers the openings in the plate which carries the magnet, through which the compressed air passes from the chamber B, through the duct 2, to the interior of the primary pneumatic C. The arm projecting from this primary pneumatic carries the twin disc-valves D and E, their stem being held in vertical position by the spring S, which is just sufficiently strong to hold the disc-valve E closed against the pressure of the compressed air

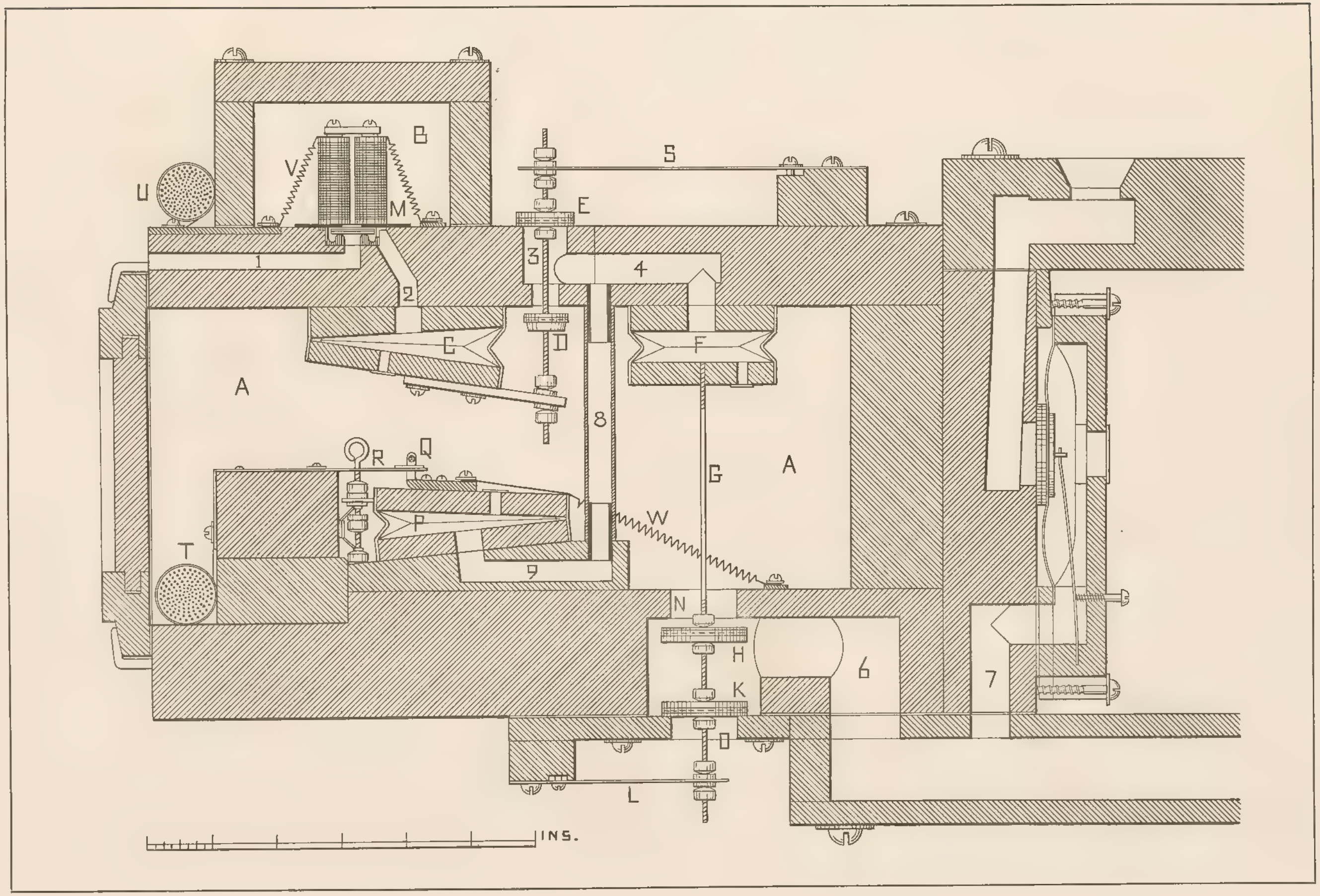
* United States Letters Patent, No. 374,088, dated November 29, 1887. Well illustrated.

† United States Letters Patent, No. 643,840, dated February 20, 1900. Fully illustrated.

which enters the valve-throat 3 from the box A. Opening from the valve-throat 3, and leading thence to the interior of the secondary pneumatic F, is the duct 4. Attached to the movable board of the pneumatic F is the valve-stem G, carrying the twin disc-valves H and K, and being held in vertical position by the light spring L. The disc-valve H commands the supply-port N, while the disc-valve K commands the exhaust-port O. From the valve-throat 5 opens the pneumatic channel 6, which extends across the wind-chest, and from which the ducts of the pouch-pneumatics open, as shown at 7. All the parts above mentioned strictly belong to the direct key action. The remaining parts belong to the coupling action. P is a small pneumatic connected with the duct 4 of the secondary pneumatic by the tube 8 and the duct 9. This pneumatic carries the coupling-bar Q, which comes in contact with the coupling-springs, one of which is indicated at R, when the pneumatic P collapses on the depression of the corresponding manual key. The pneumatic is expanded by the action of a small wire spring, the end view of which is given. At T is indicated the coupling cable, and at U the key-action cable, while at V and W are indicated the wires leading to the positive pole of the battery or generator. The operations of the appliance are extremely simple and may be described as follows:

When the manual key is depressed, the electric circuit is closed, and the magnet M is excited, drawing up the armature, cutting off connection between the compressed-air chamber B and the duct 2, and opening communication between the interior of the primary pneumatic C and the open air, through the ducts 2 and 1. The primary pneumatic instantly collapses under the pressure of the compressed air in the box A, raising the disc-valve D and closing the valve-throat 3, and also raising the disc-valve E, placing the interior of the secondary pneumatic in communication with the open air, through the duct 4 and the valve-throat 3. The secondary pneumatic now collapses, drawing up the disc-valve H so as to close the supply-port N, and the disc-valve K so as to open the exhaust port O. The pouch-pneumatics now exhaust into the open air through the pneumatic channel 6 and the port O, and the corresponding pipes speak. When the secondary pneumatic F exhausts, the coupler pneumatic also exhausts through the duct 9, the tube 8, the duct 4, and the valve-throat 3. In collapsing it brings the coupling-bar Q into contact with the spring R, completing the circuit (provided the coupler is drawn at the claviers), and sending the electric current to the electro-magnet of the same note in the Swell or any other division of the Organ. There are as many coupling-springs placed under the coupling-bar as there are couplers. The couplers are all electrically connected and disconnected by switches operated by draw-knobs at the claviers. When the manual key is released, the exact reverse of the above-described movements takes place, and the appliance resumes the state of inoperative rest indicated in the Plate.

The formation of even a fairly reliable and durable key contact in which sparking is prevented has always been a difficulty. It is absolutely essential that provision be made for automatic cleaning of the surfaces which complete the circuit, and that all liability to burning be eliminated. If platinum could be afforded for all contacts all such matters would adjust themselves. In Mr. W. B. Fleming's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patent of 1901* a good key contact is described. In this device a metal plate is screwed on the upper surface of the key tail, carrying at its free end a small transverse piece, preferably of silver wire. The "contact-finger" is a spring plate, on the under side of the free end of which a corresponding piece of silver wire is attached diagonally. When the key is depressed, the pieces of silver wire come together with a sliding motion, preventing the liability to undue wear or burning out at any given point. In ordinary forms of the electric action used in Organs, the key contacts are simply a series of spring or bent wires against which contact plates or other bent wires rub when the keys are depressed. The forms of these contact wires vary considerably, but the principle of their operation is in all cases identical. In keys which are pivoted at any place between their noses and tails, the contacts are properly made at their tails; but when they are pivoted at their tails,—by no means an unusual method in electro-pneumatic Organs,—the contacts are made at some convenient spot between their noses and tails. It is questionable if the perfect form of contact has been invented, notwithstanding the numerous expedients and treatments resorted to by different experts.

In the year 1895 Mr. Edwin S. Votey took out three patents connected with the electro-pneumatic Organ.† All the appliances protected are connected with the pneumatic ventil wind-chest; and while they cannot fail to be of interest to the student of the art of organ-building, they do not illustrate any essentially new principle, and, accordingly, call for no description in these brief notes.

In the year 1898 Mr. Ernest M. Skinner, Organ Builder, of Boston, Mass., took out a patent for several valuable inventions.‡ In the preamble of his Specification the inventor says:

> "This invention relates to improvements in Organs; and it has for its object the eradication of the heretofore objectionable features of the electric organ action.
>
> "My improved electrical coupler has for its object to accomplish by a novel arrangement of the circuits on the key-action magnets a reduction in the number of key contacts necessary for successful operation of the Organ. By the employment of a veneer of metal of uniform thickness in the construction of the magnet-boxes, all necessity for regulation in the armature-valves is obviated. By the single contact a perfectly simultaneous response from every division of the Organ is obtained, the regulation of the contacts much simplified, and the liability of derangements reduced to a minimum. The closed circuit is employed in the stop action with devices for preventing undue waste of electricity. By the employment of swing sides the size of the portable consoles is much reduced, thereby making them portable in a much more practical sense of the term."

While there are in this patent several more or less valuable appliances, that which is most important and which introduces a new principle in construction, is the novel form of electro-magnet. In the claims made by the inventor we find the following:

*United States Letters Patent, No. 666,658, dated January 29, 1901.

†United States Letters Patent—"Electrically-Controlled Magnet and Valve for Pipe-Organs," No. 536,975, dated April 2, 1895; "Electro-pneumatic Stop-Action for Pipe-Organs," No. 536,978, dated April 2, 1895; "Electro-Magnet for Pipe-Organs," No. 546,834, dated September 24, 1895.

‡United States Letters Patent, No. 11,669, dated June 14, 1898. (Reissued) Serial No. 667,945.

"In a pipe-organ action electro-magnets having a plurality of independent windings, an independent energizing-circuit for each winding, including a key contact and an intermediate switch-plate or switch, a return-wire common to all the independent energizing-circuits, and a suitable source of electric energy.

"In a pipe-organ action magnets having cable windings composed of two or more insulated strands of wire, each in electrical circuit with a single one of the various keys or stops of the organ action, and so connected that a current through any one of said windings will fully energize the magnet."

The utility of the above method of plural winding in connection with coupling actions must be at once evident. The cores of the magnets are provided with as many independent circuits or windings as there are keys of the same designation to which they are to be coupled, all circuits having a common return. For example, the Swell Organ magnet may have four separate or distinct windings; namely, that for its own-note circuit; that for the Swell to Choir coupler; that for the Swell to Great coupler, and that for the Swell to Pedal coupler. The inventor says:

"To these may be added as many more as may be desired. I have used eight upon each magnet and have seen no deterioration in the effectiveness or the practicability of the system. In a magnet constructed in this manner it might be supposed that induction would affect the action of the magnet detrimentally; but this is not the case I have the magnet-windings made in two, three, and four strand cables, and do not carry any of the circuits around more than one leg of the magnet. This method of winding must not in any way be confounded with the practice of winding several wires on one magnet and attaching the ends together. It should be distinctly understood that although they have a common return the several circuits in each magnet employed by me are independent of each other, and each circuit is supplied with current from a separate source which has no connection with any of the other circuits upon the same magnet."

We specially commend the study of Mr. Skinner's patent Specification to all interested in electricity applied to organ mechanism. The same inventor's console, having swing sides or stop-jambs that may be placed at any angle convenient to the performer, is an admirable and compact contrivance. Such a console is only practicable when an electro-pneumatic action is used. All the draw-stop knobs with their suitable contact devices are carried by and contained within the swinging sides or jambs of the console.

We may conclude the present Chapter with a few words respecting the action patented by Mr. Robert Hope-Jones, in connection with the ordinary slider and pallet wind-chest.* The appliance we specially direct attention to is simply a pneumatic lever commanded by an extremely delicate and sensitive electro-magnetic action. The pneumatic lever, in the form of an ordinary cuneiform power-bellows, acts, by means of a pull-down wire, on the pallet of the wind-chest, in the old-fashioned method. The electro-magnet may be first described substantially in the words of the patentee. The magnet is very small, preferably of a horse-shoe form, and wound with a quantity of fine insulated wire, so as to secure a high re-

* English Letters Patent, No. 15,461, accepted Sept. 26, 1891. Patent applied for Sept. 30, 1890.

sistance. Its armature is a very light and small disc of soft iron ("which may, if desired, be tinned or varnished, and may be coated with a thin soft material such as paper, kid, cloth, etc."). This disc is so arranged that, in its normal position, it lies very close indeed to the poles of the magnet, the disc forming, in fact, the armature of the magnet and the primary valve of the electro-magnetic lever. The valve-seat is a small tube of brass, the lower end of which has a plate or nipple, bearing about eighteen very small projections, each one of which is pierced with a hole just large enough to let a No. 5 sewing needle pass through. The projections are ground perfectly flat, so as to receive the disc-valve air-tight. This formation of the valve-seat, which allows the compressed air to pass in between the small projections, counterbalances to a considerable extent the pressure of the air on the under surface of the valve. To open all the holes in the valve-seat to the full extent required, the electro-magnet has only to draw away from its seat the disc-valve to a distance equal to one-fourth the diameter of the holes, or, say, about the thickness of a sheet of ordinary letter paper. The magnet is formed of soft iron wire about ⅛ inch in diameter, it is about 2⅝ inches long, and ½ inch wide across its poles. From an examination of the magnet used we should judge that its resistance is about 50 ohms. Magnets of much higher resistance can be used with great advantage. In the electro-pneumatic action employed by Mr. Thomas C. Lewis, the distinguished English organ builder, the magnets belonging to the clavier action have a resistance of 250 ohms, while those connected with the exhaust action have a resistance of 550 ohms. Alluding to these facts Mr. Lewis remarks: "With this arrangement I can play an Organ for several months with the use of only three Leclanche cells." This matter of resistance should receive most careful consideration by all interested in electricity applied to organ construction.

In the pneumatic appliance under present consideration, the small primary disc-valve, above described, allows compressed air to enter into, or exhaust from, a small cuneiform, secondary pneumatic. This carries a large disc-valve, which opens and closes two ports alternately; allowing compressed air to enter the pneumatic lever and to draw down the wind-chest pallet when the corresponding key is depressed, and to place the interior of the pneumatic lever in direct communication with the open air when the key is released and at rest. There is, of course, absolutely nothing novel in this pneumatic action.

There are several other electro-pneumatic appliances described and illustrated in the Specification of Patent No. 15,461; but as the application of the electro-magnetic force is alike in principle in all of them it is unnecessary for them to be described here. The number of electro-pneumatic appliances is considerably increased by those embraced in Mr. R. Hope-Jones' other patents taken out in the years 1890 and 1891.* The fully-illustrated Specifications of these patents may be consulted with great advantage by all who are interested in the application of electricity to organ mechanism.

* English Letters Patent, No. 18,803, accepted November 14, 1891. Patent applied for November 20, 1890; and No. 18,073, accepted October, 1892. Patent applied for October 21, 1891.

SPECIFICATIONS.

I. THE ORGAN IN THE CENTENNIAL HALL, SYDNEY, N. S. W.

THERE had never before been so grand an opportunity in the organ-building world for the production of a truly great work, displaying all the science and art connected with organ construction and tonal appointment, as that afforded by the Competition for the Organ to be placed in the Centennial Hall, Sydney, N. S. W., and yet that golden opportunity passed without establishing a single noteworthy step in tonal appointment, save in the mere matter of size, in advance of what had been achieved long before. The Competition resulted in the appointment of Messrs. W. Hill and Son, Organ Builders, London. We had the privilege of examining the Organ while in course of construction and have nothing but unqualified praise to express respecting the high-class and skilful workmanship displayed in its fabrication. The following is the Specification of the stops and mechanical accessories of the instrument:

PEDAL ORGAN

Compass CCC to F = 30 notes.

1. Double Open Diapason	32	Ft.	14. Bass Flute	8	Ft.
2. Double Open Diapason	32	"	15. Twelfth	$5\frac{1}{3}$	"
3. Contra-Bourdon	32	"	16. Fifteenth	4	"
4. Open Diapason	16	"	17. Mixture	II.	Ranks.
5. Open Diapason	16	"	18. Mixture	III.	Ranks.
6. Violone	16	"	19. Mixture	IV.	Ranks.
7. Gamba	16	"	20. Contra-Trombone	64	Ft.
8. Dulciana	16	"	21. Contra-Posaune	32	"
9. Bourdon	16	"	22. Posaune	16	"
10. Quint	$10\frac{2}{3}$	"	23. Trombone	16	"
11. Octave	8	"	24. Bassoon	16	"
12. Prestant	8	"	25. Trumpet	8	"
13. Violoncello	8	"	26. Clarion	4	"

FIRST CLAVIER—CHOIR ORGAN

Compass CC to c^4 = 61 notes.

27. Contra-Dulciana	16	Ft.	29. Gamba	8	Ft.
28. Open Diapason	8	"	30. Dulciana	8	"

31.	Flauto Traverso	8 Ft.	39.	Fifteenth	2 Ft.
32.	Hohlflöte	8 "	40.	Dulcet	2 "
33.	Lieblichgedeckt	8 "	41.	Dulciana Mixture	III. Ranks.
34.	Octave	4 "	42.	Bassoon*	16 Ft.
35.	Violino	4 "	43.	Vox Humana*	8 "
36.	Celestina	4 "	44.	Clarinet*	8 "
37.	Lieblichflöte	4 "	45.	Oboe*	8 "
38.	Twelfth	2⅔ "	46.	Octave Oboe*	4 "

I. Tremolant.

The five reed stops marked (*) are inclosed in a swell-box, controlled by a special expression-lever.

SECOND CLAVIER—GREAT ORGAN

Compass CC to c^4=61 notes.

47.	Contra-Bourdon (Tenor C)	32 Ft.	61.	Harmonic Flute	4 Ft.
48.	Double Open Diapason	16 "	62.	Principal	4 "
49.	Bourdon	16 "	63.	Octave	4 "
50.	Open Diapason, No. 1	8 "	64.	Gemshorn	4 "
51.	Open Diapason, No. 2	8 "	65.	Twelfth	2⅔ "
52.	Open Diapason, No. 3	8 "	66.	Fifteenth	2 "
53.	Open Diapason, No. 4	8 "	67.	Mixture	III. Ranks.
54.	Harmonic Flute	8 "	68.	Cymbal	IV. Ranks.
55.	Viola	8 "	69.	Sharp Mixture	IV. Ranks.
56.	Spitzflöte	8 "	70.	Fourniture	V. Ranks.
57.	Gamba	8 "	71.	Contra-Posaune	16 Ft.
58.	Hohlflöte	8 "	72.	Posaune	8 "
59.	Rohrflöte	8 "	73.	Trumpet	8 "
60.	Quint	5⅓ "	74.	Clarion	4 "

THIRD CLAVIER—SWELL ORGAN

Compass CC to c^4=61 notes.

75.	Double Open Diapason	16 Ft.	87.	Twelfth	2⅔ Ft.
76.	Bourdon	16 "	88.	Fifteenth	2 "
77.	Open Diapason	8 "	89.	Harmonic Piccolo	2 "
78.	Viola da Gamba	8 "	90.	Mixture	IV. Ranks.
79.	Salicional	8 "	91.	Fourniture	V. Ranks.
80.	Dulciana	8 "	92.	Trombone	16 Ft.
81.	Vox Angelica	8 "	93.	Bassoon	16 "
82.	Hohlflöte	8 "	94.	Horn	8 "
83.	Octave	4 "	95.	Cornopean	8 "
84.	Gemshorn	4 "	96.	Oboe	8 "
85.	Harmonic Flute	4 "	97.	Trumpet	8 "
86.	Rohrflöte	4 "	98.	Clarion	4 "

FOURTH CLAVIER—SOLO ORGAN

Compass CC to c^4=61 notes.

99.	Quintaton	16 Ft.	109.	Flauto Traverso	2 Ft.
100.	Open Diapason	8 "	110.	Contra-Tuba	16 "
101.	Violin Diapason	8 "	111.	Contrafagotto	16 "
102.	Flauto Traverso	8 "	112.	Corno di Bassetto	16 "
103.	Doppelflöte	8 "	113.	Harmonic Trumpet	8 "
104.	Stopped Diapason	8 "	114.	Tuba	8 "
105.	Viola	8 "	115.	Cor Anglais	8 "
106.	Octave	4 "	116.	Orchestral Oboe	8 "
107.	Flauto Traverso	4 "	117.	Octave Oboe	4 "
108.	Harmonic Flute	4 "	118.	Tuba Clarion	4 "

II. Tremolant.

FIFTH CLAVIER—ECHO ORGAN

Compass CC to c^4=61 notes.

119. VIOLE D'AMOUR	8 Ft.	123. FLAGEOLET	2 Ft.
120. UNDA MARIS (II. Ranks)	8 "	124. ECHO DULCIANA CORNET	IV. Ranks.
121. LIEBLICHGEDECKT	8 "	125. GLOCKENSPIEL	IV. Ranks.
122. VIOLE D'AMOUR	4 "	126. BASSET-HORN	8 Ft.

COUPLERS

1. Swell to Choir, Unison coupler.
2. Swell to Great, Unison coupler.
3. Swell, Octave coupler on itself.
4. Swell, Sub coupler on itself.
5. Choir to Great, Unison coupler.
6. Solo to Great, Unison coupler.
7. Solo to Choir, Unison coupler.
8. Echo to Swell, Unison coupler.
9. Solo, Octave coupler on itself.
10. Choir to Pedal coupler.
11. Great to Pedal coupler.
12. Swell to Pedal coupler.
13. Solo to Pedal coupler.
14. Pedal to Great Organ pistons.

COMBINATION PISTONS

Seven Pistons to Choir Organ.
Eight Pistons to Great Organ.
Eight Pistons to Swell Organ.
Seven Pistons to Solo Organ.
Three Pistons to Echo Organ.

COMBINATION FOOT-LEVERS

Four Foot-levers to Great Organ.
Six Foot-levers to Pedal Organ.
Foot-lever to Choir Tremolant.
Foot-lever to Solo Tremolant.
Three Foot-levers to Couplers Nos. 11, 12, and 13.

EXPRESSION-LEVERS

1. Expression-lever to Choir Organ reed stops.
2. Expression-lever to Swell Organ stops.

For the benefit of the reader who may have only a very superficial knowledge of the science and art of organ appointment we offer the following few remarks on the tonal scheme of this immense Organ. To the reader who has studied our views anent the tonal appointment of the Concert-room Organ, as clearly enunciated in our Chapter on that form of instrument, a glance at the above Specification will be sufficient to show how impossible it would be for us to say anything in high commendation of the tonal appointment therein set forth.

At the outset, and with much regret, we must say we fail to observe, with the single exception of the unique CONTRA-TROMBONE, 64 FT., a single feature or disposition in the long list of stops and mechanical accessories which marks an onward step or an attempt to break through old-time traditions. Indeed, in certain directions there is a positive falling-off from previously established models.

The most complete and satisfactory portion of the instrument is, unquestionably, the Pedal Organ with its impressive series of twenty-six stops. It is calculated to meet every demand that can possibly be made upon it by the tonal combinations desirable in the manual divisions. The CONTRA-TROMBONE, 64 FT., for obvious acoustical reasons may be passed over here without comment. Why are there no expressive stops?

The Great Organ is cast in a good old-fashioned mould, and is chiefly noteworthy for its massing of pure organ-tone, furnished (after the pattern set by the Organ in St. George's Hall, Liverpool) by the DOUBLE OPEN DIAPASON, and the four OPEN DIAPASONS. In combination with these the four harmonic-corroborating and four compound stops form a fairly complete harmonic structure.

Turning to the Swell Organ—the only complete division inclosed in a swell-box—we are bound to pronounce it insufficient for so immense an instrument. Under the circumstances that the flexibility and expressive powers of the Organ depend almost entirely on this division, it should most certainly have been larger and richer in its tonal appointment than

the Great Organ. Instead of being so, it has four stops less in number, and is, generally considered, much less assertive and brilliant in tone. The three additional reed stops, which are not of powerful voice, do not in any way make up for the tameness of the labial stops. All this would not be so serious a shortcoming if there was another important division of the instrument, preferably the Solo Organ, inclosed and rendered flexible and expressive.

The Choir Organ, in association with the Great and Swell divisions, is decidedly colorless. It is in its tonal appointment very similar to the Swell Organ, being simply softer in general tone. Here, as in every other manual division, there has been no consistent attempt to produce distinctive local coloring by an artistic grouping of any of the distinctive families of stops. The only noteworthy feature in the Choir Organ is the inclosure of its five reed stops in a special swell-box. This is a small step in so large a work, but it is one in the right direction. The total number of expressive stops in the Organ is twenty-nine,—less than one-fourth of the number of stops contained in all the divisions,—a very poor showing for a Concert-room Organ.

Little need be said respecting the tonal appointment of the Solo Organ. Beyond three or four of its reed stops, this division contains only three stops which may be considered of an orchestral character suitable for solo effects. Indeed, on a careful analysis of its tonal appointment, it is somewhat difficult to realize on what grounds it is designated the Solo Organ. A Solo Organ entirely devoid of flexibility and powers of expression is surely an anomalous absurdity in a concert-room instrument. Why was such an absurdity perpetrated in this case? The grouping of the three FLUTES of the same class is a desirable feature here.

The Echo Organ furnishes another example of an unexpressive division. How many are the inartistic shortcomings which mark this colossal instrument as an old-fashioned specimen of organ-building.

II. ORGAN FOR THE CENTENNIAL HALL, SYDNEY,

AS SCHEMED BY MR. HILBORNE L. ROOSEVELT

IT is our privilege to lay before the organ-loving reader the Specification submitted in the Competition for the Sydney Organ by America's renowned organ-builder, the late Mr. Hilborne L. Roosevelt, of New York. This Specification has never before been made public; and is given here for its suggestive value, and so that it may be compared with the Specification of the executed Organ now in the Centennial Hall. The comparison of the two schemes, if conducted in an unprejudiced spirit, cannot fail to be profitable to the student of the art of organ-building. We direct special attention to the powers of flexibility and expression provided, and to the completeness of the mechanical appliances and accessories.

PEDAL ORGAN

Compass CCC to F = 30 notes.

1. DOUBLE OPEN DIAPASON	32	Ft.	14. FLUTE	8	Ft.
2. DOUBLE OPEN DIAPASON	32	"	15. OCTAVE QUINT	5⅓	"
3. CONTRA-BOURDON	32	"	16. SUPER-OCTAVE	4	"
4. OPEN DIAPASON	16	"	17. OCTAVE FLUTE	4	"
5. OPEN DIAPASON	16	"	18. CORNET	V.	Ranks.
6. VIOLONE	16	"	19. MIXTURE	VI.	Ranks.
7. GAMBA	16	"	20. CONTRA-BOMBARD (Free reed)	32	Ft.
8. STOPPED DIAPASON	16	"	21. BOMBARD (Free reed)	16	"
9. DULCIANA	16	"	22. TROMBONE	16	"
10. QUINT	10⅔	"	23. BASSOON	16	"
11. OCTAVE	8	"	24. CLARION	8	"
12. OCTAVE	8	"	25. OBOE CLARION	8	"
13. VIOLONCELLO	8	"	26. OCTAVE CLARION	4	"

All the stops of the Pedal Organ to speak on wind of 4 inches. No stops expressive.

FIRST CLAVIER—GREAT ORGAN

Compass CC to c^4 = 61 notes.

27.	Contra-Bourdon (FF)	32 Ft.
28.	Double Open Diapason	16 "
29.	Double Melodia	16 "
30.	Open Diapason	8 "
31.	Bell Diapason	8 "
32.	Violin Diapason	8 "
33.	Gemshorn*	8 "
34.	Viola da Gamba*	8 "
35.	Flûte Harmonique	8 "
36.	Principalflöte	8 "
37.	Doppelflöte	8 "
38.	Rohrflöte*	8 "
39.	Quint*	5⅓ "
40.	Octave	4 "
41.	Gambette*	4 Ft.
42.	Flûte Harmonique	4 "
43.	Rohrflöte*	4 "
44.	Tierce*	3⅕ "
45.	Octave Quint*	2⅔ "
46.	Super-octave*	2 "
47.	Piccolo Harmonique*	2 "
48.	Mixture*	V. Ranks.
49.	Fourniture*	V. Ranks.
50.	Scharf*	VI. Ranks.
51.	Double Trumpet*	16 Ft.
52.	Trumpet*	8 "
53.	Baryton*	8 "
54.	Clarion*	4 "

Stops marked (*) to be inclosed in the Choir Organ swell-box No. 1. The Great Organ stops to speak on wind of 4 inches.

SECOND CLAVIER—CHOIR ORGAN

Compass CC to c^4 = 61 notes.

55.	Double Dulciana	16 Ft.
56.	Open Diapason	8 "
57.	Geigenprincipal	8 "
58.	Viole d'Amour	8 "
59.	Dulciana	8 "
60.	Melodia	8 "
61.	Lieblichgedeckt	8 "
62.	Quintadena	8 "
63.	Octave	4 "
64.	Fugara	4 "
65.	Dulcet	4 Ft.
66.	Flûte d'Amour	4 "
67.	Nasard	2⅔ "
68.	Flageolet	2 "
69.	Dolce Cornet	V. Ranks.
70.	Euphone (Free reed)	16 Ft.
71.	Clarinet	8 "
72.	Oboe	8 "
73.	Oboe Clarion	4 "
I.	Tremolant.	

All the stops of the Choir Organ to be inclosed in swell-box No. 1, which will also contain seventeen stops of the Great Organ. All the stops of the Choir Organ to speak on wind of 3 inches.

THIRD CLAVIER—SWELL ORGAN

Compass CC to c^4 = 61 notes.

74.	Double Open Diapason	16 Ft.
75.	Bourdon	16 "
76.	Open Diapason	8 "
77.	Flûte á Pavillon	8 "
78.	Spitzflöte	8 "
79.	Bell Gamba	8 "
80.	Salicional	8 "
81.	Dolce	8 "
82.	Vox Cœlestis	8 "
83.	Flauto Traverso	8 "
84.	Hohlflöte	8 "
85.	Stopped Diapason	8 "
86.	Octave	4 "
87.	Salicet	4 "
88.	Flauto Traverso	4 "
89.	Hohlflöte	4 Ft.
90.	Flauto Dolce	4 "
91.	Octave Quint	2⅔ "
92.	Super-octave	2 "
93.	Flauto Piccolo	2 "
94.	Cornet	IV., V., VI., Ranks.
95.	Acuta	IV. Ranks.
96.	Orphicleide	16 "
97.	Contrafagotto	16 "
98.	Tuba	8 "
99.	Cornopean	8 "
100.	Oboe	8 "
101.	Euphone (Free reed)	8 "
102.	Vox Humana	8 "
103.	Clarion	4 "
II.	Tremolant.	

All the Swell Organ stops to be inclosed in swell-box No. 2, and to speak on wind of 3½ inches.

FOURTH CLAVIER—SOLO ORGAN

Compass CC to c^4 = 61 notes.

104.	Contra-Gamba	16 Ft.
105.	Stentorphone	8 "
106.	Violoncello	8 Ft.
107.	Concert Flute	8 "

108. Philomela	8	Ft.
109. Viola	4	"
110. Concert Flute	4	"
111. Hohlpfeife	4	"
112. Piccolo Harmonique	2	"
113. Corno di Bassetto	16	"
114. Trompette Harmonique	8	"
115. Cor Anglais	8	Ft.
116. Orchestral Oboe	8	"
117. Orchestral Clarinet	8	"
118. Tuba Major	16	"
119. Tuba Mirabilis	8	"
120. Tuba Clarion	4	"
III. Tremolant.		

All the stops of the Solo Organ to be inclosed in swell-box No. 3. Stops Nos. 104 to 117 to speak on wind of 4½ inches. Stops Nos. 117 to 120 to speak on wind of 10 inches.

FIFTH CLAVIER—ECHO ORGAN

Compass CC to $c^4 = 61$ notes.

121. Quintaten	16	Ft.
122. Open Diapason	8	"
123. Keraulophone	8	"
124. Unda Maris	8	"
125. Fernflöte	8	"
126. Dulcet	4	Ft.
127. Flûte Harmonique	4	"
128. Harmonia Ætheria	IV.	Ranks.
129. Corno Dolce	8	Ft.
130. Vox Humana	8	"
IV. Tremolant.		

The Solo Organ to be situated in attic. All the stops to be inclosed in swell-box No. 4, commanded by the balanced expression-lever of the Solo Organ. All stops to speak on wind of 2½ inches.

COUPLERS

1. Swell to Great, Unison coupler.
2. Choir to Great, Unison coupler.
3. Solo to Great, Unison coupler.
4. Great to Swell, Unison coupler.
5. Solo to Swell, Unison coupler.
6. Swell to Choir, Unison coupler.
7. Solo to Choir, Unison coupler.
8. Echo to Choir, Unison coupler.
9. Swell, Octave coupler on itself.
10. Swell, Sub coupler on itself.
11. Solo, Octave coupler on itself.
12. Echo, Octave coupler on itself.
13. Great to Pedal coupler.
14. Choir to Pedal coupler.
15. Swell to Pedal coupler.
16. Solo to Pedal coupler.
17. Echo to Pedal coupler.

All to be controlled by draw-stop knobs. All couplers to be included in the piston combinations. Couplers Nos. 1, 3, 4, to be controlled also by foot-levers.

ROOSEVELT DIVISION SHUT-OFF KNOBS

1. Great Organ Shut-off, affecting all the Great Organ stops.
2. Pedal Organ Shut-off, affecting all the Pedal Organ stops.

Adjustable, to shut off any combination of stops without disturbing the draw-stop knobs.

ROOSEVELT ADJUSTABLE COMBINATION PISTONS

1 to 10. Ten Pistons under Great Organ clavier, affecting all Great and Pedal Organ stops and Couplers Nos. 1, 2, 3, 13, 14, 15, 16, 17.

11 to 17. Seven Pistons under Choir Organ clavier, affecting all Choir stops, Tremolant I., and Couplers Nos. 6, 7, 8.

18 to 27. Ten Pistons under Swell Organ clavier, affecting all Swell stops, Tremolant II., and Couplers Nos. 4, 5, 9, 10.

28 to 34. Seven Pistons under Solo Organ clavier, affecting all Solo stops, Tremolant III., and Coupler No. 11.

35 to 37. Three Pistons under Echo Organ clavier, affecting all Echo Organ stops, Tremolant IV., and Coupler No. 12.

FOOT-LEVER MOVEMENTS.

1 to 8. Eight Roosevelt Adjustable Combination-levers, affecting Pedal Organs tops and Couplers Nos. 13, 14, 15, 16, 17.

9. Crescendo and Diminuendo-lever for the whole tonal forces of the Organ.

REVERSIBLE FOOT-LEVERS

1. For Swell to Great coupler.
2. For Solo to Great coupler.
3. For Great to Swell coupler.
4. For Great to Pedal coupler.
5. For Swell to Pedal coupler.
6. For Solo to Pedal coupler.
7. For Swell Organ Tremolant.
8. For Choir Organ Tremolant.
9. For Solo Organ Tremolant.
10. For Echo Organ Tremolant.
11. For Great Organ Shut-off.
12. For Pedal Organ Shut-off.

EXPRESSION-LEVERS

1. Balanced Expression-lever for Choir Organ and inclosed section of Great Organ—Swell-box No. 1.
2. Balanced Expression-lever for Swell Organ—Swell-box No. 2.
3. Balanced Expression-lever for Solo Organ and Echo Organ—Swell-boxes Nos. 3 and 4.

It will be observed, in reviewing the tonal appointment in the above scheme, that even in the case of so progressive a builder as Mr. Roosevelt unquestionably was, the clogging influence of tradition was too strong to permit a radical departure from old models. There is, accordingly, no novelty in the arrangement or apportionment of the tonal forces in his scheme. He, however, evidenced a clear perception of the necessities of the Concert-room Organ in the appointment of the Swell Organ. He properly made it numerically stronger in speaking stops than any other manual division; and whilst the executed instrument contains only ten unison stops in its Swell division, Mr. Roosevelt's scheme provides fifteen of unison pitch. A comparatively weak Swell Organ would not have been so serious a shortcoming in Mr. Roosevelt's instrument as it unquestionably is in the executed Organ, which contains only one complete division in a swell-box.

It is certainly remarkable, if anything that organ builders do, or do not do, in the artistic treatment of the Organ can be considered remarkable, that Mr. Roosevelt, after giving the maximum of flexibility and expression to all the manual divisions, neglected the provision of expressive powers to some section of the Pedal Organ stops. This omission is all the more remarkable from the fact that he possessed a fine musical sense; and that he knew what had already been done in this important direction by Germany's greatest organ-builders—Messrs. Walcker, of Ludwigsburg.

As we have spoken of other matters connected with Mr. Roosevelt's notable scheme in certain pages of our text, it is unnecessary to enlarge on its merits or shortcomings here. We may conclude by expressing our surprise at the Sydney authorities passing over a scheme which, with all its faults, would have established a new epoch, at that time, in the art of organ-building.

III. THE ORGAN IN ST. GEORGE'S HALL, LIVERPOOL

THE Grand Organ in St. George's Hall, at Liverpool, unquestionably is, with all its many shortcomings, the noblest Concert-room Organ from a tonal point of view in the world to-day. The Organ was constructed in the year 1855 by the late Henry Willis, the most distinguished organ builder Great Britain has produced, from the Specification prepared by Dr. S. S. Wesley. It was tuned, in accordance with Dr. Wesley's old-fashioned ideas, in unequal temperament, and remained in that objectionable and inconvenient condition until 1867, when the late Mr. W. T. Best, Organist to the Corporation of Liverpool, suggested several tonal improvements, including the tuning to equal temperament. These were skilfully carried out by Mr. Willis.

Subsequent to the resignation of Mr. Best, and on the appointment of Dr. A. L. Peace, a complete renovation of the Organ was decided on. This was carried

out by Mr. Willis. The altered Organ was inaugurated on March 5th, 1898, by two Recitals given by Dr. Peace. The most radical change consisted in the alteration of the original compass of the manual divisions—GGG to a^3—to the compass of CC to c^4. The following is the Specification of the Organ as it now stands:

PEDAL ORGAN

Compass CCC to G = 32 notes.

1. Double Open Diapason	32	Ft.	10. Fifteenth	4	Ft.
2. Double Open Diapason	32	"	11. Fourniture	V.	Ranks.
3. Open Diapason	16	"	12. Mixture	III.	Ranks.
4. Open Diapason	16	"	13. Posaune	32	Ft.
5. Salicional	16	"	14. Posaune	16	"
6. Bourdon	16	"	15. Ophicleide	16	"
7. Principal	8	"	16. Trumpet	8	"
8. Principal	8	"	17. Clarion	4	"
9. Quint	5⅓	"			

FIRST CLAVIER—CHOIR ORGAN

Compass CC to c^4 = 61 notes.

18. Double Diapason	16	Ft.	27. Gamba	4	Ft.
19. Open Diapason	8	"	28. Twelfth	2⅔	"
20. Clarabella	8	"	29. Fifteenth	2	"
21. Stopped Diapason	8	"	30. Flageolet	2	"
22. Dulciana	8	"	31. Sesquialtera	III.	Ranks
23. Viola da Gamba	8	"	32. Trumpet	8	Ft.
24. Vox Angelica	8	"	33. Cremona	8	"
25. Principal	4	"	34. Orchestral Oboe	8	"
26. Harmonic Flute	4	"	35. Clarion	4	"

SECOND CLAVIER—GREAT ORGAN

Compass CC to c^4 = 61 notes.

36. Double Open Diapason	16	Ft.	49. Twelfth	2⅔	Ft.
37. Open Diapason	8	"	50. Fifteenth	2	"
38. Open Diapason	8	"	51. Harmonic Piccolo	2	"
39. Open Diapason	8	"	52. Doublette	II.	Ranks.
40. Open Diapason	8	"	53. Sesquialtera	III.	Ranks.
41. Stopped Diapason	8	"	54. Mixture	IV.	Ranks.
42. Violoncello	8	"	55. Trombone	16	Ft.
43. Quint	5⅓	"	56. Trombone	8	"
44. Principal	4	"	57. Ophicleide	8	"
45. Principal	4	"	58. Trumpet	8	"
46. Viola	4	"	59. Clarion	4	"
47. Flute	4	"	60. Clarion	4	"
48. Tenth	3⅕	"			

THIRD CLAVIER—SWELL ORGAN

Compass CC to c^4 = 61 notes.

61. Double Open Diapason	16	Ft.	71. Twelfth	2⅔	Ft.
62. Open Diapason	8	"	72. Fifteenth	2	"
63. Open Diapason	8	"	73. Fifteenth	2	"
64. Dulciana	8	"	74. Piccolo	2	Ft.
65. Viola da Gamba	8	"	75. Doublette	II.	Ranks.
66. Stopped Diapason	8	"	76. Fourniture	V.	Ranks.
67. Voix Céleste	8	"	77. Trombone	16	Ft.
68. Principal	4	"	78. Contra-Hautboy	16	"
69. Octave Viola	4	"	79. Ophicleide	8	"
70. Flute	4	"	80. Trumpet	8	"

81. Horn	8	Ft.	84. Clarion	4	Ft.
82. Oboe	8	"	85. Clarion	4	"
83. Clarinet	8	"	I. Tremolant		

The stops in the Swell Organ are inclosed in a spacious swell-box, and are flexible and expressive.

FOURTH CLAVIER—SOLO ORGAN

Compass CC to c^4=61 notes.

86. Open Diapason*	8	Ft.	94. Vox Humana*	8	Ft.
87. Viola da Gamba*	8	"	95. Orchestral Oboe*	8	"
88. Stopped Diapason*	8	"	96. Corno di Bassetto*	8	"
89. Orchestral Flute*	4	"	97. Ophicleide	8	"
90. Piccolo*	2	"	98. Trumpet	8	"
91. Contrafagotto*	16	"	99. Clarion	4	"
92. Trombone*	8	"	100. Clarion	4	"
93. Bassoon*	8	"	II. Tremolant		

The stops marked (*) are inclosed in a special swell-box, and are rendered flexible and expressive. The stops Nos. 97, 98, 99, 100 are on wind of 22 inches, and are exposed and unexpressive.

COUPLERS

1. Swell to Choir, Unison coupler.
2. Swell to Great, Octave coupler.
3. Swell to Great, Unison coupler.
4. Swell to Great, Sub coupler.
5. Choir, Octave coupler on itself.
6. Choir, Sub coupler on itself.
7. Choir to Great, Unison coupler.
8. Solo to Great, Unison coupler.
9. Solo, Octave coupler on itself.
10. Solo, Sub coupler on itself.
11. Choir to Pedal coupler.
12. Great to Pedal coupler.
13. Swell to Pedal coupler.
14. Solo to Pedal coupler.

COMBINATION PISTONS

Six Pistons to Pedal Organ.
Six Pistons to Choir Organ.
Six Pistons to Great Organ.
Six Pistons to Swell Organ.
Six Pistons to Solo Organ.

The Pistons of the Choir, Great, Swell, and Solo Organs are situated underneath their respective claviers; while those of the Pedal Organ are placed in convenient positions at the ends of the claviers.

COMBINATION FOOT-LEVERS

Four Combination Foot-levers commanding the combinations on the Swell Organ also commanded by Pistons Nos. 3, 4, 5, and 6 of the same division. Six Combination Foot-levers commanding the combinations on the Great Organ and Pedal Organ also commanded by the Pistons of these two divisions combined.

EXPRESSION-LEVERS

1. Expression-lever to Swell Organ.
2. Expression-lever to Solo Organ.

The most marked defect in the mechanical appointment of this important instrument is the absence of an automatic adjustable combination action. All the combinations on its thirty thumb-pistons and ten foot-levers are *fixed* ones, which cannot be altered by the performer at the keys without immediate manipulation of the draw-stop knobs. This deficiency handicaps the organist to a most undesirable extent.

In criticising the tonal structure and stop appointment of the Organ one must bear in mind with whom they originated. Dr. S. S. Wesley was saturated with old-time ideas, clinging even to the long-condemned and barbarous system of tuning in unequal temperament. To him a Concert-room Organ was merely a large Church Organ placed in a concert-room; and, accordingly, called for no special tonal appointment. To him the Open Diapason and its derivatives were of overwhelming importance: accordingly, we find in the eighty-three stops in the four manual divisions no fewer than three Double Open Diapasons, nine Open Diapasons, four Principals, three Twelfths, and four Fifteenths. The multiplication

of stops of the same name and class is somewhat remarkable: there are four Stopped Diapasons, three Ophicleides, four Trumpets, and seven Clarions.

While in pure organ-tone and in reed-tone this instrument is unsurpassed by any Organ in the world, it is sadly deficient in imitative string-tone. It contains only one Violoncello, three Viola da Gambas, and two Violas (4 ft.) in the manual divisions; and while none of these is highly imitative, they are so distributed in the four divisions as to render an effective massing of string-tone an impossibility. In the manual department there are twenty-nine reed stops, and, fine as they all are, some of them could well be spared to secure the introduction of other voices which the Organ is at present sadly deficient in.

Grand as the Pedal Organ is, it cannot be pronounced sufficient in tonal variety. It is certainly deficient in soft-toned and imitative voices. A Dulciana, 16 ft., a small-scaled, imitative Contra-Basso, 16 ft., and a Contrafagotto, 16 ft., of orchestral quality, would be invaluable additions.

The stop appointments of the Choir and Great Organs need not be criticised; they are simply good specimens of old-fashioned methods. How far they are suitable for the modern Concert-room Organ will remain a matter of opinion. There is no doubt, however, that the full tone of the Great Organ is singularly massive and grand.

Before the recent renovation, the Swell Organ was the only expressive division in the instrument; for in the year 1855 the introduction of more than a single swell-box was neither appreciated nor understood. It is, indeed, remarkable that for upwards of forty years the Solo Organ of fifteen stops, including four high-pressure reeds, remained uninclosed and entirely devoid of flexibility and powers of expression; and, to our mind, it is still more remarkable that when the swell-box was applied to the Solo Organ in 1898, the four high-pressure and very powerful reed stops were left uninclosed. It is not too much to say that had these noisy stops been placed under control their utility and effectiveness would have been increased tenfold. In our opinion, while it was right to inclose the eleven stops of the Solo Organ, it was positively barbarous to leave the very stops which call most loudly for tonal control in the whole Organ absolutely uncontrollable.

IV. ORGAN IN FIRST CONGREGATIONAL CHURCH, GREAT BARRINGTON, MASS.

THE Organ erected in the year 1883 in the First Congregational Church Great Barrington, Massachusetts, U. S. A., is one of the notable church instruments constructed by the late Mr. Hilborne L. Roosevelt. The following is the list of the speaking stops and mechanical accessories and appliances of this interesting and instructive Organ:

PEDAL ORGAN

Compass CCC to F = 30 notes.

1. Contra-Bass (Resultant)	32	Ft.	5. Violoncello	8	Ft.
2. Open Diapason	16	"	6. Flute	8	"
3. Dulciana	16	"	7. Trombone	8	"
4. Bourdon	16	"			

FIRST CLAVIER—CHOIR ORGAN

Compass CC to a^3 = 58 notes.

8. Contra-Gamba	16	Ft.	15. Fugara	4	Ft.
9. Open Diapason	8	"	16. Flûte d'Amour	4	"
10. Viola d'Amore	8	"	17. Piccolo Harmonique	4	"
11. Dulciana	8	"	18. Dolce Cornet	V.	Ranks.
12. Concert Flute	8	"	19. Clarinet	8	Ft.
13. Rohrflöte	8	"	20. Vox Humana	8	"
14. Quintadena	8	"	I. Tremolant.		

The Choir Organ stops are inclosed in swell-box No. 1, which is confined to this division.

ECHO ORGAN

Compass CC to $a^3 = 58$ notes.

21. Keraulophone	8 Ft.	24. Oboe	8 Ft.
22. Fernflöte	8 "	25. Vox Humana	8 "
23. Flauto Traverso	4 "	II. Tremolant.	

The Echo Organ is played from the Choir Organ clavier, to which it can be connected and disconnected at the performer's pleasure.

SECOND CLAVIER—GREAT ORGAN

Compass CC to $a^3 = 58$ notes.

26. Double Open Diapason	16 Ft.	35. Gambette	4 Ft.
27. Open Diapason (Large)	8 "	36. Flûte Harmonique	4 "
28. Open Diapason (Small)	8 "	37. Octave Quint*	$2\frac{2}{3}$ "
29. Gemshorn	8 "	38. Super-octave*	2 "
30. Viola da Gamba	8 "	39. Mixture*	IV. Ranks.
31. Principalflöte	8 "	40. Scharf*	III. Ranks.
32. Doppleflöte	8 "	41. Euphone*	16 Ft.
33. Quint*	$5\frac{1}{3}$ "	42. Trumpet	8 "
34. Octave	4 "		

* Stops Nos. 33, 37, 38, 39, 41, 42 are inclosed in swell-box No. 2, in which are inclosed the Swell Organ stops.

THIRD CLAVIER—SWELL ORGAN

Compass CC to $a^3 = 58$ notes.

43. Bourdon	16 Ft.	52. Salicet	4 Ft.
44. Open Diapason	8 "	53. Flauto Dolce	4 "
45. Spitzflöte	8 "	54. Hohlflöte	4 "
46. Salicional	8 "	55. Flageolet	2 "
47. Dolce	8 "	56. Cornet	III., IV., & V. Ranks.
48. Vox Cœlestis	8 "	57. Contrafagotto	16 Ft.
49. Clarabella	8 "	58. Cornopean	8 "
50. Stopped Diapason	8 "	59. Oboe	8 "
51. Octave	4 "	60. Clarion	4 "

III. Tremolant.

All the stops of the Swell Organ are inclosed in swell-box No. 2, in which are inclosed six stops of the Great Organ.

COUPLERS

1. Choir to Great, Unison coupler.
2. Swell to Great, Unison coupler.
3. Swell to Choir, Unison coupler.
4. Swell, Octave coupler on itself.
5. Choir to Pedal coupler.
6. Great to Pedal coupler.
7. Swell to Pedal coupler.

ROOSEVELT ADJUSTABLE COMBINATION PISTONS

1 to 3. Three Pistons under Choir clavier, affecting Choir Stops, Swell to Choir and Choir to Pedal Couplers, and Choir Tremolant.

4 to 8. Five Pistons under Great clavier, affecting Great and Pedal Stops, and Swell to Great, Choir to Great, and Great to Pedal Couplers.

9 to 13. Five Pistons under Swell clavier, affecting Swell Stops, and Swell and Swell to Pedal Couplers, and Swell Tremolant.

FOOT-LEVER MOVEMENTS

1–3. Three Adjustable Combination Levers affecting Pedal Stops.

4. Choir "off" Echo "on" Ventil.
5. Piano Pedal Ventil.
6. Great to Pedal Reversible Coupler.
7. Balanced Expression-lever to Choir Organ.
8. Balanced Expression-lever to Great and Swell Organs.

While the apportionment of the tonal forces in the different divisions of this instrument presents no special departure from old-fashioned models, the great dignity which pervades its manual department deserves recognition. In this department are five stops of 16 ft. pitch, and no fewer than twenty-eight unison or 8 ft. stops. This appointment leaves only

twenty manual stops for all pitches under 8 feet. The student of the art of organ-building should take special notice of the manner in which powers of flexibility and expression are given to the main manual divisions. The Swell Organ, of eighteen stops, is inclosed in the large swell-box which also holds the seven expressive stops of the Great Organ. This is a departure, so far as the latter stops are concerned, from Mr. Roosevelt's favorite practice, which was to inclose the expressive stops of the Great Organ in the Choir Organ swell-box, leaving the Swell Organ entirely independent. The Echo Organ, so seldom met with in a proper treatment, and yet so productive of beautiful tonal effects, is here a division of five speaking stops, situated as high up as possible in an extension of the main building, which is separated from the body of the church by a solid wall in rear of the pulpit. The action of this division is electro-pneumatic. It will be observed that there are two Vox Humanas commanded by the First Clavier, enabling the performer to produce very beautiful and uncommon effects by the use of the Choir "off" Echo "on" Ventil, accompaniments being played on the Swell Organ.

V. THE ORGAN IN THE AUDITORIUM, CHICAGO, ILL.

THIS important and noteworthy Concert-room Organ was constructed by the late Mr. Frank Roosevelt,—successor to the late Mr. Hilborne L. Roosevelt,—of New York, from the Plans and Specification and under the personal superintendence of Mr. Walter F. Crosby, the accomplished and efficient Manager of the Roosevelt Organ Works. It is not too much to say that, in certain directions, the conception and construction of this instrument marked an epoch in the history of the organ-builder's art. It is much to be regretted that the architectural arrangements were of so undesirable a character as to seriously handicap the builder of the Organ; and are now such as to destroy much of the true musical effects that the instrument itself is capable of producing. The following is the Specification of the stop appointment and mechanical accessories of this Organ:

PEDAL ORGAN

Compass CC to F = 30 notes.

1. Double Open Diapason	32 Ft.	11. Flute	8 Ft.
2. Contra-Bourdon	32 "	12. Octave Quint	5⅓ "
3. Open Diapason	16 "	13. Super-octave	4 "
4. Open Diapason	16 "	14. Mixture	III. Ranks.
5. Dulciana	16 "	15. Contra-Bombard	32 Ft.
6. Violone	16 "	16. Trombone	16 "
7. Stopped Diapason	16 "	17. Serpent (Free reed)	16 "
8. Quint	10⅔ "	18. Contra-Bassoon	16 "
9. Octave	8 "	19. Clarion	8 "
10. Violoncello	8 "		

FIRST CLAVIER—CHOIR ORGAN

Compass CC to c^4 = 61 notes.

20. Double Melodia	16 Ft.	29. Flûte d'Amour	4 Ft.
21. Open Diapason	8 "	30. Nazard	2⅔ "
22. Geigenprincipal	8 "	31. Piccolo	2 "
23. Dulciana	8 "	32. Dolce Cornet	V. Ranks.
24. Flauto Traverso	8 "	33. Euphone (Free reed)	16 Ft.
25. Lieblichgedeckt	8 "	34. Tromba	8 "
26. Quintadena	8 "	35. Clarinet	8 "
27. Octave	4 "	36. Carillon (Steel bars F to c^4)	
28. Fugara	4 "	I. Tremolant.	

All the stops of the Choir Organ are inclosed in swell-box No. 1, and are, accordingly, flexible and expressive.

SECOND CLAVIER—GREAT ORGAN

Compass CC to c^4=61 notes.

37. Double Open Diapason	16 Ft.	47. Octave	4 Ft.
38. Contra-Gamba	16 "	48. Gambette*	4 "
39. Open Diapason	8 "	49. Flûte Harmonique*	4 "
40. Open Diapason	8 "	50. Octave Quint*	$2\frac{2}{3}$ "
41. Gemshorn	8 "	51. Super-octave*	2 "
42. Viola da Gamba*	8 "	52. Mixture*	IV. & V. Ranks.
43. Viola d'Amore*	8 "	53. Scharf*	III. & IV. Ranks.
44. Principalflöte	8 "	54. Ophicleide*	16 Ft.
45. Doppelflöte*	8 "	55. Trumpet*	8 "
46. Quint*	$5\frac{1}{3}$ "	56. Clarion*	4 "

The stops marked (*) are inclosed in swell-box No. 2, and are, accordingly, flexible and expressive. The remaining seven stops are the only ones in the entire manual department of the Organ which are uninclosed and devoid of flexibility.

THIRD CLAVIER—SWELL ORGAN

Compass CC to c^4=61 notes.

57. Double Dulciana	16 Ft.	69. Salicet	4 Ft.
58. Bourdon	16 "	70. Hohlflöte	4 "
59. Open Diapason	8 "	71. Flauto Dolce	4 "
60. Violin Diapason	8 "	72. Flageolet	2 "
61. Spitzflöte	8 "	73. Cornet	IV. & V. Ranks.
62. Salicional	8 "	74. Acuta	III. Ranks.
63. Æoline	8 "	75. Contrafagotto	16 Ft.
64. Vox Cœlestis	8 "	76. Cornopean	8 "
65. Flûte Harmonique	8 "	77. Oboe	8 "
66. Clarabella	8 "	78. Vox Humana	8 "
67. Stopped Diapason	8 "	79. Clarion	4 "
68. Octave	4 "	II. Tremolant.	

All the stops of the Swell Organ are inclosed in swell-box No. 3, and are, accordingly, flexible and expressive.

FOURTH CLAVIER—SOLO ORGAN

Compass CC to c^4=61 notes.

80. Stentorphone	8 Ft.	88. Basset Horn	16 Ft.
81. Violoncello	8 "	89. Tuba Mirabilis	8 "
82. Concert Flute	8 "	90. Orchestral Oboe	8 "
83. Viola	4 "	91. Orchestral Clarinet	8 "
84. Flûte Octaviante	4 "	92. Cor Anglais	8 "
85. Hohlpfeife	4 "	93. Tuba Clarion	4 "
86. Piccolo Harmonique	2 "	94. Chimes (25 Tubular Bells).	
87. Tuba Major	16 "	III. Tremolant.	

All the stops of the Solo Organ, with the exception of the Chimes, are inclosed in swell-box No. 4. The wind-pressure of this division is 8 inches.

FOURTH CLAVIER—ECHO ORGAN

Compass CC to c^4=61 notes.

95. Quintaten	16 Ft.	101. Flauto Traverso	4 Ft.
96. Keraulophone	8 "	102. Harmonia Ætheria	IV. Ranks.
97. Dolcissimo	8 "	103. Horn	8 "
98. Unda Maris	8 "	104. Oboe	8 "
99. Fernflöte	8 "	105. Vox Humana	8 "
100. Dulcet	4 "	IV. Tremolant.	

All the stops of the Echo Organ are inclosed in swell-box No. 5, which is located above the ceiling of the hall, at a distance of about one hundred feet from the main instrument. The Echo Organ is played from the Fourth Clavier, to which it can be connected at will, the Solo division being disconnected at the same instant.

FOURTH CLAVIER—STAGE ORGAN

Compass CC to c^4=61 notes.

106. Open Diapason	8 Ft.	108. Octave	4 Ft.
107. Doppleflöte	8 "	109. Trumpet	8 "

The stops of the Stage Organ are inclosed in a special movable box on the stage, and are played from the Fourth Clavier, being brought on or shut off by means of a ventil.

COUPLERS

1. Swell to Great, Unison coupler.
2. Choir to Great, Unison coupler.
3. Solo to Great, Unison coupler.
4. Swell to Choir, Unison coupler.
5. Swell, Octave coupler on itself.
6. Solo, Octave coupler on itself.
7. Choir to Pedal coupler.
8. Great to Pedal coupler.
9. Swell to Pedal coupler.
10. Solo to Pedal coupler.

All couplers are commanded by draw-knobs, and are included in the Piston combinations.

ROOSEVELT ADJUSTABLE COMBINATION PISTONS

1 to 5. Five Pistons affecting the Choir and Pedal Stops, Couplers Nos. 4 and 7, and Tremolant I.
6 to 12. Seven Pistons affecting Great and Pedal Stops, and Couplers Nos. 1, 2, 3, and 8.
13 to 20. Eight Pistons affecting Great and Pedal Stops, Couplers Nos. 5 and 9, and Tremolant II.
21 to 25. Five Pistons affecting Solo and Pedal Stops, Couplers Nos. 6 and 10, and Tremolant III.

ADJUSTABLE COMBINATION LEVERS

1 to 5. Five Foot-levers affecting Pedal Organ Stops and Pedal Couplers Nos. 7, 8, 9, and 10.

FOOT-LEVER MOVEMENTS

1. Full Organ Lever, drawing all speaking Stops without throwing out the draw-stop knobs. 2. Echo Organ Ventil Lever. 3. Stage Organ Ventil Lever. 4. Pedal Organ Ventil Lever, silencing any adjustable selection of Pedal Organ Stops without throwing in the draw-stop knobs. 5. Solo Organ "Off" Echo Organ "On" Ventil Lever. 6. Solo to Great Reversible Coupler Lever. 7. Swell Octave Reversible Coupler Lever. 8. Solo Octave Reversible Coupler Lever. 9. Great to Pedal Reversible Coupler Lever. 10. Solo to Pedal Reversible Coupler Lever.

EXPRESSION-LEVERS, ETC.

1. Balanced Expression-lever to Great and Choir Organs. 2. Balanced Expression-lever to Swell Organ. 3. Balanced Expression-lever to Solo and Echo Organs. 4. Lever to open all swell-boxes. 5. Lever to close all swell-boxes. 6. Crescendo-lever, affecting all the speaking stops in the instrument. 7. Diminuendo-lever, affecting all the speaking stops in the instrument. 8. Crescendo and Diminuendo Indicator. 9. High-pressure Wind Indicator. 10. Medium-pressure Wind Indicator. 11. Low-pressure Wind Indicator.

In reviewing the above Specification one cannot avoid being impressed with its general conception, while, at the same time, one must recognize the fact that it does not present all that is to be desired in a Concert-room Organ of the first rank. In the directions in which the Auditorium Organ falls short of what is to be desired, precedent has been followed and old-fashioned methods adhered to. Tradition seems to have been all too strong for even such cultivated minds as were concentrated on its production. In these remarks we particularly allude to the insufficiency or absence of special tonal coloring and grouping in the stop apportionment of the manual divisions of the instrument, and the total absence of flexibility and powers of expression in its pedal department.

On referring to the Specification, it will be observed that no definite system of classification has been followed in the apportionment of the truly noble series of speaking stops to the different manual divisions which form the main body of the instrument; namely, the Great, Choir, and Swell Organs. Either of these divisions would make a satisfactory manual department for a small Organ, because a sufficient variety of tonality obtains in each division to render it independent. Now, we maintain that in a properly-appointed Concert-room Organ no such thing as tonal independence in the several manual divisions should exist, a partial concession being made only with respect to the First Organ or organ-toned division. On the contrary, not only should they be dependent one on the other, but each division should have a clearly defined office in the general scheme of the instrument, and possess a marked and distinct relative tonal coloring. Our ideas on this important subject are treated with some degree of fullness in the Chapter on the Concert-room Organ, and need not be enlarged on here.

While we do not consider it necessary to go into details connected with the stop appointment of the different divisions of the Auditorium Organ, we may point out to the student of the art of organ-building that in no case, save in that of the Great Organ, is there any evidence of an attempt toward tonal classification and stop grouping. In the Great Organ the tonal structure is fairly complete so far as pure organ-tone is concerned; but beyond this there is not a single family of stops gathered together in any of the divisions of the instrument. The Organ generally is deficient in imitative string-tone ; and is, accordingly, crippled to a serious extent for the proper rendition of orchestral scores. It will be seen, on referring to the Specification of the Third Organ in our Chapter on the Concert-room Organ, how important we consider the proper provision and grouping of orchestral string-tone.

In stop-appointment, the Pedal Organ is about as satisfactory as any other division of the instrument. Here the greatest diversity of quality and strength of tone is necessary, so that suitable basses can be found for all the usual and desirable combinations in the manual divisions. The shortcomings of the pedal department under review are its limited tonal resources for so large an instrument, and its total want of flexibility and powers of expression. As we have remarked elsewhere, it is extremely difficult to understand on what logical or musical grounds the Pedal Organ is almost invariably left without powers of expression. In an instrument which has, out of the eighty-four speaking stops in its manual divisions, only seven stops uninclosed, the total absence of flexibility and powers of expression in its Pedal Organ stops is as remarkable as it is to be regretted. On this important subject a further discussion will be found in our Chapter on the Swell in the Organ.

From both an artistic and practical point of view the position of this immense instrument is a huge mistake. Not only is it buried in a deep and comparatively narrow chamber, but it is hidden behind an obstructive, meaningless, and intensely ugly screen, about the center of which is a semicircular grille, of bizarre design, through the openings of which nearly all the sound, which naturally flows from the labial pipe-work in a horizontal direction, finds egress. The lower portion of this screen, to a line considerably above the front of the first tier of boxes is completely solid. Above this screen is a lunette filled with what would pass for a portcullis of a mediæval castle, so chaste is its design, through which the sound from the instrument is allowed to pass. Judging, however, from the following passage which appears in a large work on the Auditorium, it would seem that this entombment of the Organ was considered an achievement to be proud of : "The only portion of the Organ visible from the stalls is the 'console' or key-box, which is a comparatively small case containing numerous keys, stops, and pistons, but absolutely nothing capable of producing a musical sound. Here are gathered within reach of the organist all the appliances for the control of every portion of the instrument, while the pipes and wind-chests are disposed in various places upon, about, and over the stage, at great distances from the console and each other. The organist is thus in plain sight from stage and stalls, and has the great advantage of being able to hear his Organ as it sounds to the audience (a rather unusual privilege), while his somewhat cumbersome instrument is almost entirely hidden from view." Further comment is unnecessary on this subject. The mechanism of the Organ is tubular- and electro-pneumatic.

VI. THE ORGAN IN ST. BARTHOLOMEW'S CHURCH, NEW YORK CITY

THE important divided Organ in Saint Bartholomew's Church, New York City, was built by Mr. George H. Hutchings, of Boston, Mass. The electro-pneumatic action employed is the invention of Mr. Ernest M. Skinner, Organ Builder, of Boston. The Organ is divided. The Gallery Organ is situated at the east end of the church, one hundred and thirty feet from the chancel, and contains Great, Swell, Solo, and Pedal Organs. The Chancel Organ is situated at the west end of the church, its Swell Organ being placed on the north side of the chancel, and its Great, Choir, and Pedal Organs on the south side of the chancel. The console is movable, weighing about four hundred pounds. It is connected with the entire instrument by a flexible cable of length sufficient to

allow the Organ to be played from any part of the church. The following is the Specification of the instrument:

PEDAL ORGAN

Compass CCC to F = 30 notes.

—GALLERY DIVISION—

1. Double Open Diapason	32 Ft.	7. Octave	8 Ft.
2. Contra-Bourdon	32 "	8. Violoncello	8 "
3. Open Diapason	16 "	9. Gedeckt	8 "
4. Contra-Basso	16 "	10. Super-octave	4 "
5. Bourdon	16 "	11. Bombarde	16 "
6. Quint	10⅔ "	12. Posaune	8 "

—CHANCEL DIVISION—

13. Open Diapason	16 Ft.	18. Octave	8 Ft.
14. Violone	16 "	19. Violoncello	8 "
15. Dulciana	16 "	20. Flute	8 "
16. Bourdon	16 "	21. Trombone	16 "
17. Quint	10⅔ "	22. Tromba	8 "

GREAT ORGAN

Compass CC to $c^4 = 61$ notes.

—GALLERY DIVISION—

23. Double Open Diapason	16 Ft.	32. Fugara	4 Ft.
24. Open Diapason	8 "	33. Flûte Harmonique	4 "
25. Violin Diapason	8 "	34. Twelfth	2⅔ "
26. Horn Diapason	8 "	35. Fifteenth	2 "
27. Gamba	8 "	36. Mixture	III. Ranks.
28. Keraulophone	8 "	37. Sesquialtera	III. Ranks.
29. Melodia	8 "	38. Ophicleide	16 Ft.
30. Rohrflöte	8 "	39. Trumpet	8 "
31. Octave	4 "	40. Clarion	4 "

—CHANCEL DIVISION—

41. Double Open Diapason	16 Ft.	47. Octave	4 Ft.
42. Open Diapason	8 "	48. Flauto Traverso	4 "
43. Open Diapason	8 "	49. Twelfth	2⅔ "
44. Gamba	8 "	50. Fifteenth	2 "
45. Concert Flute	8 "	51. Mixture	V. Ranks.
46. Doppelflöte	8 "	52. Trumpet	8 Ft.

SWELL ORGAN

Compass CC to $c^4 = 61$ notes.

—GALLERY DIVISION—

53. Bourdon	16 Ft.	59. Flûte d'Amour	4 Ft.
54. Open Diapason	8 "	60. Super-octave	2 "
55. Salicional	8 "	61. Cornet	III. Ranks.
56. Dolce	8 "	62. Harmonic Trumpet	8 Ft.
57. Stopped Diapason	8 "	63. Cor Anglais	8 "
58. Octave	4 "	64. Vox Humana	8 "

I. Tremolant.

—CHANCEL DIVISION—

65. Bourdon	16 Ft.	71. Stopped Diapason	8 Ft.
66. Open Diapason	8 "	72. Quintadena	8 "
67. Gemshorn	8 "	73. Octave	4 "
68. Salicional	8 "	74. Salicet	4 "
69. Vox Cœlestis	8 "	75. Flûte Harmonique	4 "
70. Æoline	8 "	76. Piccolo	2 "

77. Dolce Mixture . . . V. Ranks.
78. Contrafagotto . . 16 Ft.
79. Cornopean . . . . . . 8 "
80. Oboe . . . . 8 Ft.
81. Oboe Clarion . . . . 4 "
II. Tremolant.

CHOIR ORGAN

Compass CC to $c^4 = 61$ notes.

—IN CHANCEL—

82. Double Dulciana . . . . 16 Ft.
83. Open Diapason . . . 8 "
84. Geigenprincipal . . . 8 "
85. Dulciana . . . . . . 8 "
86. Clarabella . . . . 8 "
87. Lieblichgedeckt* . . . 8 "
88. Gemshorn* . . . . 4 Ft.
89. Waldflöte . . . . 4 "
90. Piccolo Harmonique* . 2 "
91. Clarinet* . . . . 8 "
92. Orchestral Oboe* . . 8 "
III. Tremolant.

The Choir Organ stops marked (*) are inclosed in a special swell-box, and are expressive and flexible.

SOLO ORGAN

Compass CC to $c^4 = 61$ notes.

—IN GALLERY—

93. Stentorphone . . . . 8 Ft.
94. Grossgamba . . . . 8 "
95. Doppelflöte . . . . . . 8 "
96. Grossflöte . 8 Ft.
97. Hohlpfeife . . 4 "
98. Tuba Mirabilis . . . 8 "

The Solo Organ stops are inclosed in a swell-box, and are, accordingly, flexible and expressive.

COUPLERS, ETC.

1. Swell to Great, Unison coupler.
2. Swell to Great, Octave coupler.
3. Choir to Great, Unison coupler.
4. Choir to Great, Sub coupler.
5. Solo to Great, Unison coupler.
6. Gallery Great Organ off.
7. Chancel Great Organ off.
8. Swell, Octave coupler on itself.
9. Swell, Sub coupler on itself.
10. Gallery Swell Organ off.
11. Chancel Swell Organ off.
12. Swell to Choir, Unison coupler.
13. Gallery Great to Solo, Unison coupler.
14. Gallery Swell to Solo, Unison coupler.
15. Chancel Great to Solo, Unison coupler.
16. Chancel Swell to Solo, Unison coupler.
17. Solo, Octave coupler on itself.
18. Solo, Sub coupler on itself.
19. Solo Organ off.
20. Great to Pedal coupler.
21. Choir to Pedal coupler.
22. Swell to Pedal coupler.
23. Solo to Pedal coupler.
24. Pedal, Octave coupler on itself.
25. Gallery Pedal Organ off.
26. Chancel Pedal Organ off.

The above Couplers and other mechanical accessories are commanded by oscillating tablets situated, in a central position, directly above the fourth manual clavier.

COMBINATION PISTONS

1 to 6. Five Combination Pistons and Release affecting Gallery Great and all Pedal Stops and Couplers.

7 to 12. Five Combination Pistons and Release affecting Chancel Great and all Pedal Stops and Couplers.

13 to 17. Four Combination Pistons and Release affecting Gallery Swell and all Pedal Stops and Couplers.

18 to 24. Six Combination Pistons and Release affecting Chancel Swell and all Pedal Stops and Couplers.

25 to 29. Four Combination Pistons and Release affecting Choir and all Pedal Stops and Couplers.

30 to 34. Four Combination Pistons and Release affecting Solo and all Pedal Stops and Couplers.

35 — One Piston releasing Gallery Organ combinations.

36 — One Piston releasing Chancel Organ combinations.

While the combinations commanded by the Pistons are practically fixed ones, provision is made in the console for any necessary changes. These changes cannot be made by the performer while seated at the keys.

FOOT-LEVER MOVEMENTS

1. Gallery Organ Antiphonal. 2. Chancel Organ Antiphonal. 3. Gallery and Chancel Organs Antiphonal. 4. Great to Pedal Coupler. 5. Full Organ. 6. Gallery Swell Organ Tremolant. 7. Chancel Swell Organ Tremolant. 8. Choir Organ Tremolant. 9. General Combination Release. 10. Pedal Organ Combination Release.

EXPRESSION-LEVERS, ETC.

1. Balanced Expression-lever to Gallery Swell Organ. 2. Balanced Expression-lever to Chancel Swell Organ. 3. Balanced Expression-lever to Choir Organ. 4. Balanced Expression-lever to Solo Organ. 5. Crescendo-lever affecting Gallery Great, Swell, and Pedal Stops. 6. Crescendo-lever affecting Chancel Organ Stops. 7. Lever connecting all other Balanced Expression-levers to Chancel Swell Expression-lever.

As a divided Church Organ, that in Saint Bartholomew's Church is both interesting and suggestive. The tonal appointments of its several manual divisions are on old-fashioned lines, and for all the legitimate offices of a Church Organ are sufficient, notwithstanding the absence of distinct local coloring which characterizes them. There is absolutely no attempt made to group the different families of stops beyond that of the DIAPASONS in the Great Organ. It is to be regretted that while 16 ft. tone is fully furnished in the Great, Swell, and Choir Organs the completion of the 16 ft. harmonic series has been neglected. Indeed, in no division is the 8 ft. harmonic series complete. The deficiency of string-tone in all the divisions, and the total absence of imitative string-toned stops in the manual department generally, render many valuable and highly desirable solo and accompanimental effects impossible. While we do not lay so much stress on the necessity of providing ample string-tone in the Church Organ as we do in the case of the Concert-room Organ, there can be no question, we venture to think, that in so large an Organ as that under review, with its seventy-six manual stops, a much larger proportion of string-tone should be available than can be supplied by one GAMBA in the Gallery Great, one GAMBA in the Chancel Great, and one GROSSGAMBA in the Solo Organ. Beyond these, there is no stop in the manual department possessing a richer string-tone than the ordinary VIOLIN DIAPASON in the Gallery Great and the GEIGENPRINCIPAL in the Choir Organ. The GROSSGAMBA, 8 FT., is the only string-toned stop in the Solo Organ. In each of the pedal divisions there is a VIOLONCELLO, 8 FT. Of the seventy-six stops in the manual department there are forty rendered expressive and flexible; and in this direction the Organ occupies a noteworthy place among church instruments. As might be expected, no attempt has been made to furnish the pedal department with any means of expression.

VII. THE "ORGUE DE SALON"

PRESENTING THE UNIQUE AND LATEST FORM OF ORGAN SPECIFICATION

UP to the middle of the year 1905, or prior to the introduction of the unique "Orgue de Salon" by The Art Organ Company, the Specifications of all Organs having two or more manual claviers were prepared in the manner which obtains in the foregoing Specifications. That is, the tonal forces of all Organs had to be divided into definite series, each of which was apportioned to, and commanded by, a special clavier; and which could not be commanded by any other clavier except through the usual crippling expedient of coupling one clavier to another. This time-honored method of stop apportionment necessitated the use of distinctive names for the divisions commanded by the different claviers; hence arose the terms Great Organ, Choir Organ, Swell Organ, Solo

Organ, etc.,—fairly expressive of the nature and purpose of the respective series of stops in these divisions. Examples of this classification and apportionment obtain in the preceding representative Specifications.

With the introduction of the "Orgue de Salon,"—the ideal Chamber Organ,—the necessity for any such classification and distinctive apportionment is entirely swept away. In the Specification of the perfect "Orgue de Salon," having a pedal and two manual claviers, only two undivided lists of speaking stops appear. These lists simply show the tonal appointments of the two departments of the instrument; namely, the pedal and manual departments. The manual claviers are absolutely untrammelled in their command of the tonal forces of the instrument. This absolute freedom of stop-grouping and unique means of tonal coloring place the "Orgue de Salon" in an unapproachable position among Chamber Organs. To realize the full meaning of this departure from old-fashioned methods, it must be understood that any combination of the stops contained in the manual department can be placed on each manual clavier, each combination having or not having certain stops in common; that while all the stops in the department may collectively be commanded by either clavier, any combination of the same stops may be commanded in a perfectly independent manner by the other clavier. Such an absolutely free and perfect system of tonal control has never before been recorded in the history of organ-building. It makes, save in the mere matter of loudness, an Organ of a large number of stops quite unnecessary. This is an all-important matter in regard to the Chamber Organ, for the reception of which good accommodation is rarely to be found outside the properly-constructed music-room. Beyond the matter of untrammelled tonal control, the "Orgue de Salon" is absolutely unique in its flexibility and powers of compound expression. In the smallest type of the two-manual instrument, the expressive powers are quadruple, while in larger types these powers are correspondingly increased. It is not too much to say that the system of tonal control, in combination with the unique powers of flexibility and compound expression, is sufficient to engender a new school of organ-playing, and to inspire musicians to write special compositions for the "Orgue de Salon."

While the manner in which the Specification for an "Orgue de Salon" is prepared seems to imply that the offices usually attributed to the different manual divisions of the ordinary Organ are abrogated, such is very far from being the case. At the will of the performer, either manual clavier can be made to represent in its tonality a true Great Organ, a complete Swell Organ, a suitable accompanimental Choir Organ, or an effective Solo Organ, each attended by a suitable Pedal Organ. Arrangements are made to enable certain stops in the manual department to be commanded by the pedal clavier, without the necessity of coupling any manual clavier to it, or interfering with the independence of the stops when drawn on the manual claviers. It is, accordingly, possible, without any aid from couplers, to have the same stops enter the three combinations commanded by the pedal and the two manual claviers; and all the three combinations can have compound expression.

To enable the performer to make any desirable changes in tonal character, the "Orgue de Salon" is provided with a complete Automatic Adjustable Combination Action; affecting both manual and pedal departments, easily manipulated at the claviers, and commanded by eight or more thumb-pistons. This action, if properly used, should render it quite unnecessary for the performer to touch a single draw-stop knob during the rendition of any ordinary composition.

In all Organs constructed on old-fashioned lines, the manual Unison couplers are indispensable, otherwise it would be impossible to form combinations of stops belonging to different divisions. In the "Orgue de Salon," the Unison couplers

are not essential accessories, simply because any combination of all the stops contained in the manual department can be immediately placed on either clavier, without resort to any couplers, or any interference with the absolute independence of the claviers. Notwithstanding this fact, the "Orgue de Salon" is provided with the full complement of manual and pedal couplers, and good use can be made of the Octave and Sub couplers, which, under the peculiar tonal capabilities of the instrument, add immensely to its combinational effects.

In the construction of the "Orgue de Salon," the Art Organ Company which has its head office in New York, N. Y., has adopted the approved Audsley-Willis Pedal Clavier of the extreme compass.

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TYPOGRAPHICAL ERRATA, ETC.

VOLUME FIRST

Page 8 line 4 up—*for* l'Egypt, *read* l'Égypt.

" 9 " 17 down—*for* Vetruvius, *read* Vitruvius.

" 12 " 6 up—*for* mèlodie, *read* mélodie.

" 13 " 4 down—*for* Transverse, *read* Longitudinal.

" 19 " 8 up—*for* Compiegne, *read* Compiègne.

" 19 " 4 up—*for* Compiegne, *read* Compiègne.

" 20 " 17 down—*for* Compiegne, *read* Compiègne.

" 26 " 22 down—*for* whole, *read* hole.

" 27 " 14 down—*for* Engle, *read* Engel.

" 30 " 14 up—*for* conventional, *read* conventual.

" 50 " 8 down—*for* Cathedrale, *read* Cathédrale.

" 53 " 15 up—*for* The compass of, *read* The range of.

" 55 " 24 down—*for* Palazzo Publico, *read* Palazzo Pubblico.

" 55 " 26 down—*for* dell Scala, *read* della Scala.

" 58 " 24 down—*for* Muhlhausen, *read* Mühlhausen.

" 64 " 15 down—*for* 1624, *read* 1724.

" 64 " 14 up—*for* Altenbourg, *read* Altenburg.

" 69 " 9 up—*for* tariter, *read* traiter.

" 69 " 7 up—*for* célebre, *read* célèbre.

" 95 " 10 up—*for* Saint-Jaques, *read* Saint-Jacques.

" 117 " 5 down—*for* In perhaps in, *read* Perhaps in.

" 119 " 4 up—*for* Edingburg, *read* Edinburgh.

" 119 " 4 up—*for* McEwen, *read* McEwan.

" 138 " 12 down—*for* Saragoza, *read* Zaragoza.

" 161 " 2 up—*for* espece, *read* espèce.

" 178 " 24 up—*for* server, *read* servir.

" 178 " 18 up—*for* voîr, *read* voir.

" 178 " 14 up—*for* frénésiede, *read* frénésie de.

" 179 " 16 up—*for* pent-être, *read* peut-être.

" 179 " 14 up—*for* senore, *read* sonore.

" 188 " 21 down—omit the superfluous "to."

" 199 " 4 up—*for* Madelaine, *read* Madeleine.

" 199 " 26 down—*for* sacrified, *read* sacrificed.

" 204 " Fig. LIII.—At the time this page was printed we had met with no example of this form of console in an American Organ. The form now obtains in certain important instruments.

Page 230 line 6 down—*for* OPHECLEIDE, *read* OPHICLEIDE.

" 234 " 2 down—*for* HOHFLÖTE, *read* HOHLFLÖTE.

" 237 " 14 up—*for* SUABEFLÖTE, *read* SUABE FLUTE.

" 238 " 15 down—*for* LIEBLICHBORDUN, *read* LIEBLICHBOURDON.

" 243 " 3 & 15 down—*for* Madelaine, *read* Madeleine.

" 252 " 14 up—*for* CREMORNE, *read* CROMORNE.

" 274 " 18 up—*for* Metal. $1\frac{1}{8}$ ft., *read* Metal. $1\frac{3}{5}$ ft.

" 274 " 17 up—*for* Metal. $1\frac{3}{5}$ ft., *read* Metal. $1\frac{1}{8}$ ft.

" 296 " 11 up—*for* DOPPLEFLÖTE, *read* DOPPELFLÖTE.

" 298 " 11 up—*for* LEIBLICHGEDECKT, *read* LIEBLICHGEDECKT.

" 305 " 1 top—*for* innnovator, *read* innovator.

" 368 " 9 up—*for* pnenomenon, *read* phenomenon.

" 373 " 3 down—*for* complétement, *read* complètement.

" 373 " 16 down—*for* parseconde, *read* par seconde.

" 374 " 12 down—*for* carée, *read* carrée.

" 374 " 21 & 27—*for* less, *read* les.

" 383 " 9 down—*for* are self-evident, *read* is self-evident.

" 387 " 5 down—*for* in on the inner, *read* is on the inner.

" 396 " 1 bottom—*for* echalote, *read* échalote.

" 397 " 12 up—*for* attends, *read* attend.

" 397 " 7 down—*for* CC to G, *read* CCC to G.

" 445 " 18 up—*for* CC to E♯, *read* CC to F♯.

" 446 " 21 up—*for* CC to D, *read* CCC to D.

" 446 " 14 up—*for* CC to F, *read* CCC to F.

" 457 " 11 up—*for* trouble, *read* trouble-.

" 467 " 16 down—*for* SEVENTEETH, *read* SEVENTEENTH.

" 438 " 6 up—*for* NINETEENTH, $1\frac{3}{5}$ FT., *read* SEVENTEENTH, $1\frac{3}{5}$ FT.

" 507 " 2 up—*for* resemblent, *read* ressemblent.

" 509 " 5 up—*for* top, *read* stop.

Page 519 line 6 down—*for* ein, *read* eine.
" 521 " 1 top—*for* un, *read* une.
" 522 " 4 down—*for* Katcher, *read* Katscher.
" 534 " 9 up—*for* s'éntendent, *read* s'étendent,
" 536 " 15 down—*for* GROSSE QUINT, *read* GROSSE QUINTE.
" 558 " 15 & 17 down—*for* REINFORZA A LIGNE, *read* RINFORZO A LINGUE.

Page 578 line 19 up—*for* OTTAVINI, *read* OTTAVINI, Basso e Soprano.
" 579 " 4 down—*for* REINFORZO, *read* RINFORZO
" 584 " 6 down—*for* stop, *read* stops
" 599 " 22 down—*for* Cornet à piston, *read* Cornet à pistons.

VOLUME SECOND

Page 8 line 14 up—*for* wind-chest, 3, *read* wind-chest, 2.
" 33 " 16 down—*for* (Ouse), *read* (Oise).
" 33 " 12 up—*for* Concert Organs, *read* Concert Organ. Omit "and the Convention Hall, Kansas City." The Organ intended for this Hall has not been placed there.
" 44 " 16 & 17—*for* The American Art Organ Company, of Los Angeles, Cal., *read* The Los Angeles Art Organ Company. The Concert Organ here alluded to was intended for, but never placed in, the Convention Hall, Kansas City,

Page 222 line 4 down—*for* peg A, *read* peg B.
" 222 " Fig. CLXI., letters B and C are omitted—B to be placed at the left end of the wire, and C at the right end of the wire.
" 246 " 4 up—*for* la compreudre, *read* le comprendre.
" 247 " 1 top—*for* licence, *read* license.

END OF VOLUME SECOND

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